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JOURNAL OF PALEONTOLOGY

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The American Association of Petroleum Geologists

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JOURNAL of PALEONTOLOGY

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JOURNAL OF PALEONTOLOGY, VOL. 6, NO. 3, PP. 225-256, PLS. 30-39, SEPTEMBER, 1932

CORALS OF THE TRINITY GROUP OF THE COMANCHEAN OF CENTRAL TEXAS

JOHN W. WELLS
Washington, D.C.

ABSTRACT

There are three main coral-bearing horizons in the Trinity group, which is the lowest of the three chief stratigraphic divisions of the Comanchean series of Texas. This paper describes 28 new species, one old species and four not specifically identified corals from the Trinity beds of central Texas. These forms are assigned to 29 genera, including three new ones, *Tiarasmilia*, *Blothrocyathus*, and *Comalia*.

INTRODUCTION

SOURCES OF MATERIAL

The larger part of the corals from the Glen Rose formation described in this paper was collected during the course of an intensive study of that formation lasting many years by Dr. F. L. Whitney of the University of Texas.

The specimens described from the Travis Peak formation were obtained through the kindness of Dr. R. H. Cuyler, also of the University of Texas, who has made a special study of that formation.

LITERATURE

Since the study of the Cretaceous corals of Texas, particularly those of the Trinity division, is an almost untouched field, literature bearing directly upon the subject is lacking. The only work of importance (and even that has a more or less remote connection) is by Felix[1] in which he has described 21 genera comprising 33 species of corals from the Neocomian beds of Tehuacan, State of Puebla, Mexico. Other than the numerous papers and monographs of Dr. T. Wayland Vaughan on Tertiary and Recent corals, I have drawn almost entirely upon European publications for information.

[1] Felix, J., Versteinerungen aus der mexicanischen Jura- und Kreideformation. *Palaeontographica* 37, th. 3, pt. 2, 1891.

CORAL HORIZONS OF THE TRINITY DIVISION

The presence of what appear to be true coral reefs in this subdivision of the Cretaceous is of great interest. At present, however, the lack of adequate knowledge of the extent and details of the reef structures prevents entering into fascinating speculations on the ecology of these fossil reefs as compared with well-known living reefs, on the significance of the association of corals and caprinids in building up these reefs, and on the presence of such reefs in the Trinity sea. A few notes on the coral

horizons must suffice for the present.

Most of the species of corals described in this paper belong to reef-building genera, some of which, such as *Orbicella*, *Siderastrea* and *Diploastrea*, are still living in the present seas, and others are extinct homologues or perhaps ancestors of living forms. In their occurrence in the Glen Rose formation they form distinct reefs at three horizons in the lower half of the formation. The Travis Peak species, while they belong to reef-building genera, do not occur in the original position of growth but have been subjected to rolling on the Travis Peak strand. Their size and shape indicate that they grew on some submarine bank but did not build up any reefs.

The first true reef appears in the heavy limestones at the base of the Glen Rose formation in the western part of Comal County. Here massive heads of *Isastrea whitneyi*, *Orbicella whitneyi*, *Astrocoenia whitneyi*, etc., are scattered about in great profusion, most of them badly weathered, although they are well enough preserved when found in place. This basal reef appears to have established itself upon a foundation consisting of large masses or layers of caprinids and attained a height of 3 to 10 feet over an area of several square miles. The number of species is not as great as in the reefs at higher horizons—6 in the basal reef, as compared with a total of 24 in the higher reefs along Blanco River.

The other reefs are similar to the basal ones in that they are built upon a foundation of caprinids, which continued to flourish as the corals grew upward. They are, however, much thicker and present a more diversified fauna. The two principal exposures of the reefs of the middle lower Glen Rose are at the Narrows of Blanco River, about 11 miles east of Blanco City, Blanco County, and in a cliff on Blanco River about one mile west of Pleasant Valley Crossing, Hays County. The reef exposed at the latter locality also outcrops nearer Pleasant Valley Crossing, near the house on Kreh's ranch where it presents a different facies from the exposure farther upstream. These reefs attain a thickness of approximately 30 feet at the Blanco Narrows, and 15 feet in the vicinity of Pleasant Valley Crossing. They are stratigraphically about 100 feet above the basal reefs, but the equivalency of the two exposures is uncertain. Several of the same species occur at both reefs but they represent different facies. At the Blanco Narrows the colonies are principally massive, rounded clumps of the type well suited to the rough water near the margins of a reef, and which are much the same as those of the basal reefs, whereas the reef exposed about a mile above Pleasant Valley Crossing presents corals of facies more suited to the quieter waters found within the reef margins—thin plate-like expansions of *Meandraraea* and *Polyphyllastrea*, tall cylindrical *Blothrocyathus* and *Siderofungia*, open clumps of *Aplosmilia* and slender branches of *Centrastrea*, although massive heads of *Astrocoenia* and *Microsolena* and thick masses of *Eugyra* are also

abundant. The associated fauna of delicate brachiopods and thin-shelled *Alectryonia* at this latter reef also indicates quieter waters. The exposure of this reef near Kreh's ranch house, however, contains many of the same species but of a facies similar to that found at the Blanco Narrows.

The third horizon is in the clayey limestones of the *Arctica roemeri* beds about 200 feet above the base of the Glen Rose. Several species occur here which have not been found at the lower horizons, although some of the reef species have been noted. All of the specimens are poorly preserved as molds of the exterior and their determination is very difficult.

Neither of the two species found in the Travis Peak formation has yet been found to occur in the Glen Rose.

But a single specimen of coral has been found in the upper Glen Rose: *Connectastrea* (?) *infundibuliformis* Wells, n. sp.

ACKNOWLEDGMENTS

I am very deeply indebted to Dr. F. L. Whitney for the opportunity of studying the Trinity corals. He has given freely of his time and experience and has made many of the photographs illustrative of the species. To Dr. T. Wayland Vaughan, who has read and revised the manuscript several times, I wish to tender my appreciation of his many kindnesses. Prof. G. D. Harris has given constant encouragement to my efforts. Thanks are also due to Dr. R. H. Cuyler for permission to study the Travis Peak corals collected during his study of that formation.

The final work on the present paper was completed during the tenure of a Storrow Fellowship of the National Research Council at the United States National Museum.

SYSTEMATIC DESCRIPTIONS

Class ANTHOZOA

Subclass HEXACORALLA Haeckel

Order MADREPORARIA Edwards

Suborder MADREPORARIA APOROSA Edwards and Haime

Family TURBINOLIDAE Edwards and Haime (emend. Verrill)

Genus TIARASMILIA Wells, n. gen.

Description. The corallum is simple, subcylindrical, or subcornute. The costae are prominent and correspond to the septa. A thick wall is formed by the thickening of the distal portions of the septa. The septa are thick, imperforate, entire on their upper margins,[2] very unequal, the large primaries being more exsert than the remainder. The primary septa extend nearly to the center where they terminate in paliform swellings which more or less fill the axial space. The sides of the septa are ribbed by vertical, parallel prolongations of the trabeculae, which, instead of producing rows of granulations or spines, form rows of thin laminae. These laminae or ridges bifurcate at their extremities and form

[2] The margin of the septum, however, is not a smooth, unbroken curve, but is divided by 3 to 4 large lobes which can hardly be called dentations.

narrow vertical plates parallel to the sides of the septa. There is no columella. No dissepiments are present and an epitheca is entirely lacking. The interseptal loculi are open throughout.

Remarks. The general appearance of this peculiar form is much like that of *Lophosmilia* E. and H., but this latter possesses a lamellar columella and different internal structure.

The specimens upon which the foregoing description is based consist of two fragments showing the upper part of the corallum and one showing the main body of the corallum but lacking the calice and base. All of them are badly preserved, the interiors being filled with crumbling grains of calcite.

The paliform swellings on the inner ends of the septa do not appear to be true pali. This, together with the lack of dissepiments, has led to the placing of this form in the Turbinolidae as it was restricted by Verrill.[3]

The type species of this genus is *T. casteri* Wells, n. sp., from the lower Glen Rose formation of Texas.

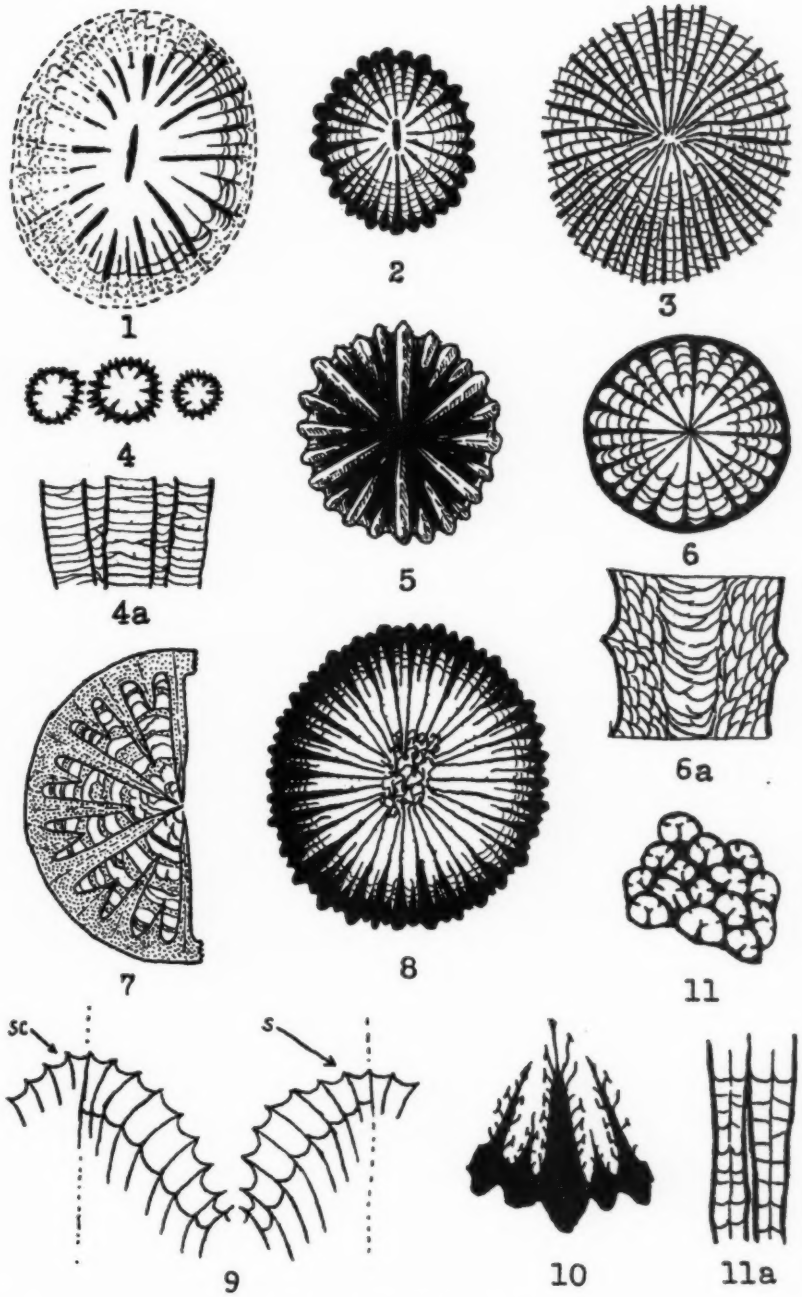
TIARASMILIA CASTERI Wells, n. sp.
Plate 30, figures 5, 10; Plate 31, figure 1

Description. Characters as of the genus described above. The corallum is simple, subcylindrical, slightly curved, tapering more or less abruptly to the base, devoid of an epitheca. The calice is circular and shallow, with a small, deep fossa. The costae are subacute and prominent, corresponding to the septa. The septa number 24, arranged in three complete cycles and six regular systems. Those of the first cycle reach nearly to the center of the corallum where they terminate in paliform swellings. For a distance of 5 mm. inward from the wall (in specimen No. 1) they

[3] Verrill, A. E., Review of the Corals and Polyps of the West Coast of North America. *Trans. Conn. Acad. Arts and Sci.*, vol. 1, p. 539, 1869.

EXPLANATION OF PLATE 30

FIGS. 1—*Peplosmilia* (?) sp. Transverse section, ×1. Diagram of septal plan. (Solid lines show actual fossil; dotted show original outline.
2—*Aplosmilia* (?) *tolmachoffana* Wells, n. sp. Transverse section, ×3. Diagram of septal plan.
3—*Thecosmilia* (?) sp. Transverse section, ×3. Diagram of septal plan.
4—*Cyathophora haysensis* Wells, n. sp. Transverse section, ×3. Diagram of three corallites. 4*a*, Longitudinal section, ×3. Diagram of three corallites.
5—*Tiarasmilia casteri* Wells, n. gen., n. sp. Diagrammatic view of calice, ×1.5.
6, 7—*Blothrocyathus harrisi* Wells, n. gen., n. sp. Transverse section, ×0.5. Diagram of septal plan. 6*a*, Longitudinal section, ×0.5. Dissepimental structure. 7, Transverse thin-section, ×1. Diagram of structure.
8—*Parasmilia bullardi* Wells, n. sp. Transverse section, ×2.5. Diagram of septal plan.
9—*Diploastrea harrisi* Wells, n. sp. Longitudinal section, ×15. Diagram of upper edges of septa as deduced from trabecular structure (*Sc*—septo-costa, *S*—septum).
10—*Tiarasmilia casteri* Wells, n. gen., n. sp. Transverse section, ×2. Gross structure of five septa.
11—*Comalia fasciculata* Wells, n. gen., n. sp. Transverse section, ×5. Diagram of corallites. 11*a*, Longitudinal section, ×5. Diagram of two corallites, showing deep calices, tabulae and main septum.



Wells, Lower Cretaceous Corals

are at least 1 mm. in thickness, but near the center they thin abruptly to 0.2 mm. or less. The septa of the second and third cycles are nearly equal in thickness at the wall to those of the first cycle, but within the corallum they are much shorter and thinner, the ratio of septal lengths, according to cycles, being about 4:2:1. The upper edges of the septa are exsert and entire. The sides of the septa are ornamented by the peculiar modification of the trabeculae described in the generic description. The average number of these laminae or ridges on one side of a primary septum is nine, evenly spaced on the thicker part of the septum.

DIMENSIONS

Specimen	*Maximum Diameter*	*Height of Corallum*
1	22.0 mm.	?
2	31.0 mm.	?
3	20.0 mm.	38.0 mm. plus

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Family ASTROCOENIIDAE Koby

Genus ASTROCOENIA Edwards and Haime, 1848

ASTROCOENIA WHITNEYI Wells, n. sp.

Plate 31, figure 6; Plate 32, figures 1, 2; Plate 37, figure 1

Description. The corallum occurs in the form of massive, convex colonies; the corallites are closely united by their walls, hexagonal or irregular, in outline. The intercalicular wall is thin. The calices are small, varying in diameter from 1.5 to 2.5 mm., in the same colony. The united raised edges are ornamented with nodes or ridges produced by the junction, over the corallite wall, of the septa of adjoining calices. The septa are always 24 in number, arranged in three cycles and six regular systems. They are granulated on their sides and denticulated on their upper edges. The primary septa are produced to the center where they unite with the columella, two of them often being slightly larger than the rest and dividing the calice. The secondary septa do not quite reach the columella and are usually much thickened or enlarged near their inner ends.[4] The third cycle of septa is developed in all of the systems, but in a few cases the whole septal arrangement is irregular. The columella is styliform and projects into the bottom of the calice, forming a prominent knob. Dissepiments are sparse.

Remarks. Two forms of this species can be recognized. The one makes tall masses which are rounded on the tops and tapered towards the base, like a gigantic strawberry. A large specimen of this type found in the reef near Pleasant Valley Crossing on Blanco River measures 100 cm. in height and 92 cm. at its greatest diameter. The other occurs as broad, flattened, convex masses on the surface of which the corallites are often clustered together in knoblike pro-

[4] This enlargement is not the same as that produced by the development of pali.

tuberances which rise to a height of 50 or 60 mm., as in *A. colliculosa* Trautschold.[5] Specimens of this type often attain a diameter of 60 cm. and a thickness (height) of 15 cm. They occur abundantly in the reef exposed at the Narrows of Blanco River. It is likely that one of these forms is a growth facies of the other, and that the variation has been produced by a difference of ecologic conditions prevailing at that time. This assumption is strengthened by the fact that the two forms have never been observed together at the same locality.

The species is characterized by the hexameral arrangement of the twelve septa and especially by the enlargement near the inner ends of the secondary septa. These features alone distinguish it from the other important species of the genus which occur in North America, as shown by the following table:

To the other species of *Astrocoenia* occurring in North America: *A. conica* Logan,[9] from the Benton group of Kansas, *A. nidiformis* Cragin,[10] from the Kiowa shale of Kansas, and *A. irregularis* Whiteaves,[11] from the lower shales of Maud Island, Canada, the present species bears little, if any, relation.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County; at the Narrows of Blanco River, Blanco County; in the basal Glen Rose in the vicinity of Spring Branch, Comal County.

ASTROCOENIA SCYPHOIDEA Wells, n. sp.
Plate 32, figure 3; Plate 33, figure 3

Description. The corallum forms a thin encrusting colony. The corallites are cup-shaped, short and crowded together. On their free edges they are covered by a stout epitheca marked by lines of growth. The calicular walls are fused together so that the calices

COMPARISON OF NORTH AMERICAN SPECIES OF *Astrocoenia*.

Species	Calicular diameter	Number of septa	Number of septa reaching columella
A. maloniana[6]	1.5–2.5 mm.	16–20	8–10
A. guadalupae[7]	2.0–2.5 mm.	24	12
A. globosa[8]	2.5 mm.	24	12
A. whitneyi	1.5–2.5 mm	24	6

[5] Trautschold, H., Le Néocomien de Sably in Crimée. *Nouv. Mém. Soc. Imp. Nat. Moscou*, vol. 15, liv. 4, p. 10, pl. 5, figs. 1a–c, 1866. Also Dietrich, W. O., Steinkorallen des Malms und der Unterkreide in südlichen Deutsch-ostafrika. *Palaeontographica*, Sup. 7, reihe 2, teil i, lief. 2. pl. 5, pl. 14, 1926.

[6] Vaughan, T. W., In Cragin, *U. S. Geol. Survey*, Bull. 266, p. 34, pl. 11, figs. 1–3, 1905.

[7] Roemer, F., Texas, etc., p. 391, 1849; Die Kreidebildungen von Texas etc., p. 87, pl. 10, figs. 8a, 8b, 1852.

[8] de Fromentel, 1880. Felix, Versteinerungen aus der mexicanischen Jura-und Kreideformation. *Palaeontographica*, bd. 37, p. 156, 1891.

[9] Logan, W. M., Contributions to the palaeontology of the upper Cretaceous. *Field. Col. Mus. Geol. Ser.*, vol. 1, 6, p. 215, pl. 26, figs. 1–3, 1899.

[10] Cragin, F. W., Descr. of the invertebr. foss. from the Comanche ser. in Texas, Kansas, and Indian Terr. *Colo. Coll. Studies*, 5th Ann. Pub., p. 50, (no fig.), 1894.

[11] Whiteaves, J. F., Mesozoic Fossils. *Can. Geol. Survey*, vol. 1, pt. 4, p. 304, (no fig.), 1900.

usually have a subpolygonal outline. These latter are small and deep, measuring 1.5–1.75 mm. in diameter and from 1.0 to 1.2 mm. in depth. The 12 septa are radially arranged in two complete cycles and six regular systems. They are relatively thick, denticulated on their upper edges and granulated laterally. The primary septa reach to the center and fuse to the columella, whereas the secondaries extend less than halfway. The columella is styliform and projects into the bottom of the calice. Dissepiments are rare.

Remarks. This species is based upon two specimens from the lower Glen Rose, one of which shows well the encrusting growth habit characteristic of the species. Duncan[12] has described several encrusting types of *Astrocoenia* from the English Liassic, but the lack of coenenchymatal tissue between the corallites and the hexameral arrangement of the septa of the Glen Rose form separates it from these Jurassic species. *A. hexaphylloides* Felix[13] from the Senonian of East Galicia, closely resembles this species but forms more massive colonies.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Family EUSMILIIDAE Verrill

Genus PARASMILIA Edwards and Haime, 1848 (pars)

PARASMILIA BULLARDI Wells, n. sp.
Plate 30, figure 8; Plate 31, figure 5

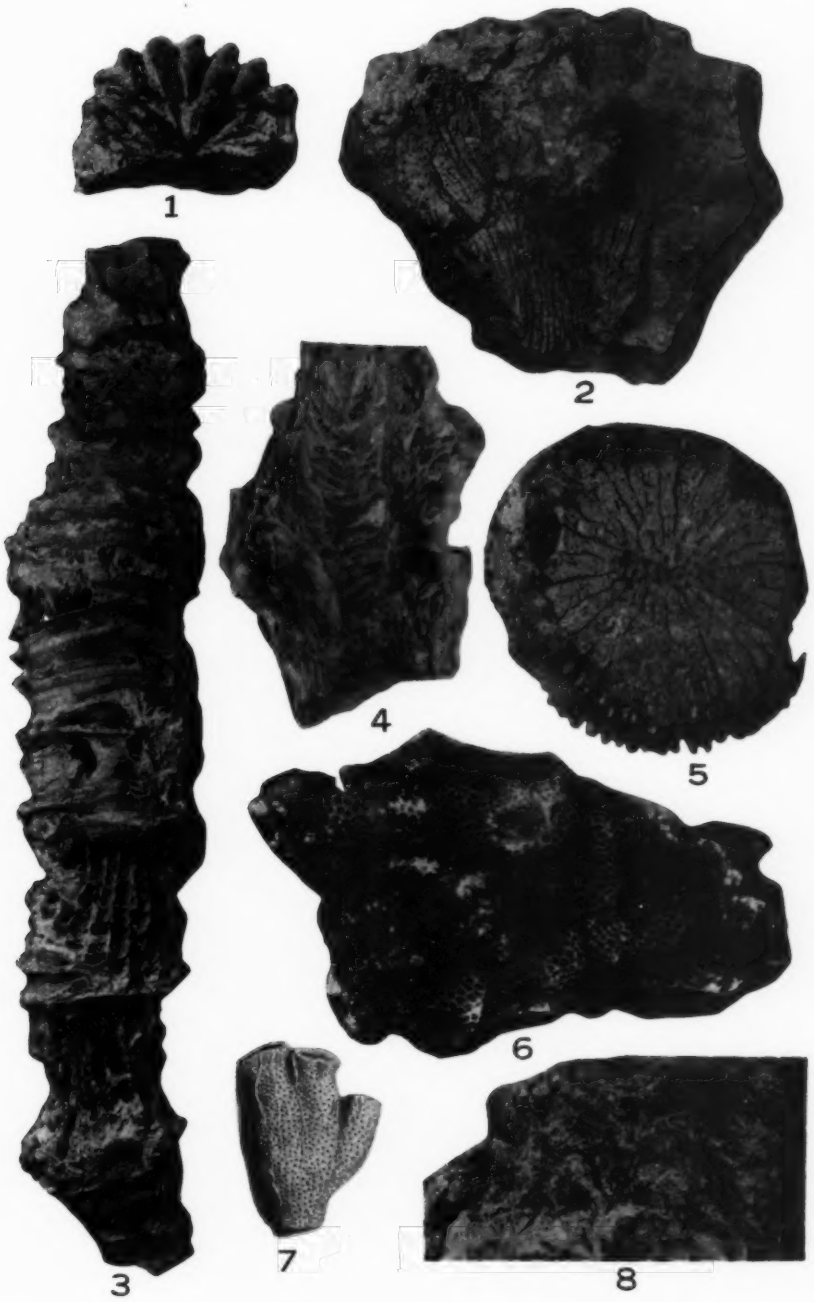
Description. The corallum is simple, short, conical and curved, measuring about 11 mm. in diameter in a slightly elliptical transverse section. The costae, which correspond to the septa, regularly alternate in size, the larger being rounded and ornamented with a row of granulations, the smaller more or less acute and smooth. The septa number 64, one-half extending to the columella, the rest short and extending less than halfway, nearly equal in thickness and laterally granulated. The columella is well-developed and vesicular. The dissepiments are confined to the peripheral area in the upper part

[12] Duncan, P. M., British Fossil Corals, 2d Series. *Palaeontographical Soc. London*, pt. 4, no. 1, 1867.
A. parasitica Duncan, p. 20, pl. 5, figs. 5, 6; *A. minuta* Duncan, p. 22, pl. 9, figs. 18–20; *A. sinemuriensis* d'Orb., p. 22.

[13] Felix, J., Ueber eine Korallenfauna aus der Kreideformation Ost-Galiziens. *Zeitschr. deutsch. geol. Ges.*, 58, p. 50, pl. 3, figs. 1, 1a, 1906.

EXPLANATION OF PLATE 31

FIGS. 1—*Tiarasmilia casteri* Wells, n. gen., n. sp. Calice of broken specimen, ×1.
2—*Aplosmilia* (?) *tolmachoffana* Wells, n. sp. Mold of exterior of corallite with one branch, ×1.
3, 4—*Blothrocyathus harrisi* Wells, n. gen., n. sp. 3, Type specimen, ×0.5.4 , Longitudinal section from type specimen, ×1.
5—*Parasmilia bullardi* Wells, n. sp. Transverse section of type specimen, ×4.
6—*Astrocoenia whitneyi* Wells, n. sp. Corallum of type specimen, ×0.5.
7—*Heterocoenia costata* Felix. Lateral view, ×3. (From Felix, 1903, for comparison with fig. 8.)
8—*Heterocoenia* (?) *hilli* Wells, n. sp. Type specimen showing mold of exterior and cast of interior, ×1.



Wells, Lower Cretaceous Corals

of the corallum, but are extensive near the base.

Remarks. This species is based upon a single specimen which had been sectioned some years ago, the extremities being lost in the process; therefore, all details concerning the calicular and basal portions are lacking. The probable dimensions of the original corallum are:

DIMENSIONS

Height of corallum	15–25 mm.
Long diameter of calice	10–12 mm.
Short diameter of calice	8–10 mm.

The affinities of this species with others can best be shown by the following table:

PRINCIPAL CHARACTERS OF SEVERAL SPECIES OF PARASMILIA

Species and locality	*Shape of corallum*	*Size of corallum*	*Septa*	*Costae*	*Calice*	*Columella*
P. bullardi nov. Glen Rose Texas	Short, conical, curved.	H: 15–25mm. D: 13×15mm?	64; 32 reach columella	Not prominent, alternate, granulate.	Slightly elliptical.	Well-developed, vesicular.
P. austinensis Roemer, Edwards ls. Texas	Turbinate, straight.	H: 27mm. D: 14×17mm.	48; 4 cycles, dentate.	Equal, fine, granulate.	Elliptical.	Vesicular.
P. texana Vaughan, Buda ls. Texas	Short, subcornute, curved.	H: 15.5mm. D: 14×10mm.	48; 4 cycles, 18 reach columella.	Alternate, larger ones prominent.	Elliptical.	Very well developed; vesicular.
P. mantelli E. & H., Senonian England.	Turbinate, straight.	H: 16–18mm. D: 11mm.	48; 4 cycles, 12 reach columella.	Equal and distinct to base.	Circular and deep.	Well-developed.
P. centralis (Mantell), Senonian England.	Turbinate-cylindric, broad base.	H: 30–50mm. D: 10mm.	48; 12 reach columella.	Close-set, larger alternate with 4th cycle near top.	Circular and quite deep.	Well-developed.
P. rudis Reuss, Senonian France.	Turbinate, curved.	H: 20mm. D: 8–9mm.	36; 18 reach columella.	Slightly unequal, distinct near calice.	Circular and deep	Well-developed.

Occurrence. 180 feet above the base of the Glen Rose in a road cut west of Esser's Crossing of Guadalupe River, Comal County.

Genus PEPLOSMILIA Edwards and Haime, 1850

PEPLOSMILIA (?) SP.
Plate 30, figure 1

Description. The corallum is simple, elliptical in transverse outline, measuring 40 mm. on the long diameter and 32 on the short. There are four complete cycles of septa, those of the first two being equal and extending nearly to the columella, those of the third cycle shorter than the preceding, and those of the last half as long as the principal ones. They are thick and straight and are united near the wall by dissepiments. The columella is lamellar, parallel to the long diameter of the corallum, and where it appears in the section it measures 7 mm. in length and is not united to any of the septa. No epi-

theca can be discerned in the Glen Rose specimen, but a fragment of an apparently identical form from the Comanche Peak formation in Williamson County shows a thin, slightly wrinkled epitheca.

Remarks. Although this is undoubtedly a new species, it is not named at present because of the poor state of preservation of the single fragment. It may belong to *Pleurosmilia*

Occurrence. In the massive beds above the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Genus APLOSMILIA d'Orbigny, 1849

APLOSMILIA (?) TOLMACHOFFANA Wells, n. sp
Plate 30, figure 2; Plate 31, figure 2

Description. The colony forms a caespitose mass. The corallites are tall, free for the greater part of their upward extent, circular or elliptical in section, with a diameter of 6 to 10 mm. The calices are not well preserved in any of the Glen Rose specimens, but in cross-section the septa number 30–36, and are unequal and straight, extending through the wall formed by septal thickening to form costae on the exterior of the corallite. These costae are usually alternate in size, spaced at intervals of 1 mm., granular on their edges, and bifurcating irregularly. The columella is lamellar and prominent. The dissepiments are abundant and are distributed principally in the outer zone of the visceral cavity. Increase is by fissiparity of the corallites, which dichotomize at distances of 2 to 4 cm. at angles of 25 to 35 degrees. There is no trace of an epitheca.

Remarks. The upper margins of the septa have not been observed in this species and for this reason the generic reference is uncertain. This form bears a close resemblance to *A. euteiches* Felix,[14] and *A. thurmanni* Koby,[15] both from the upper Jurassic (Malm), but has smaller corallites with about the same number of septa.

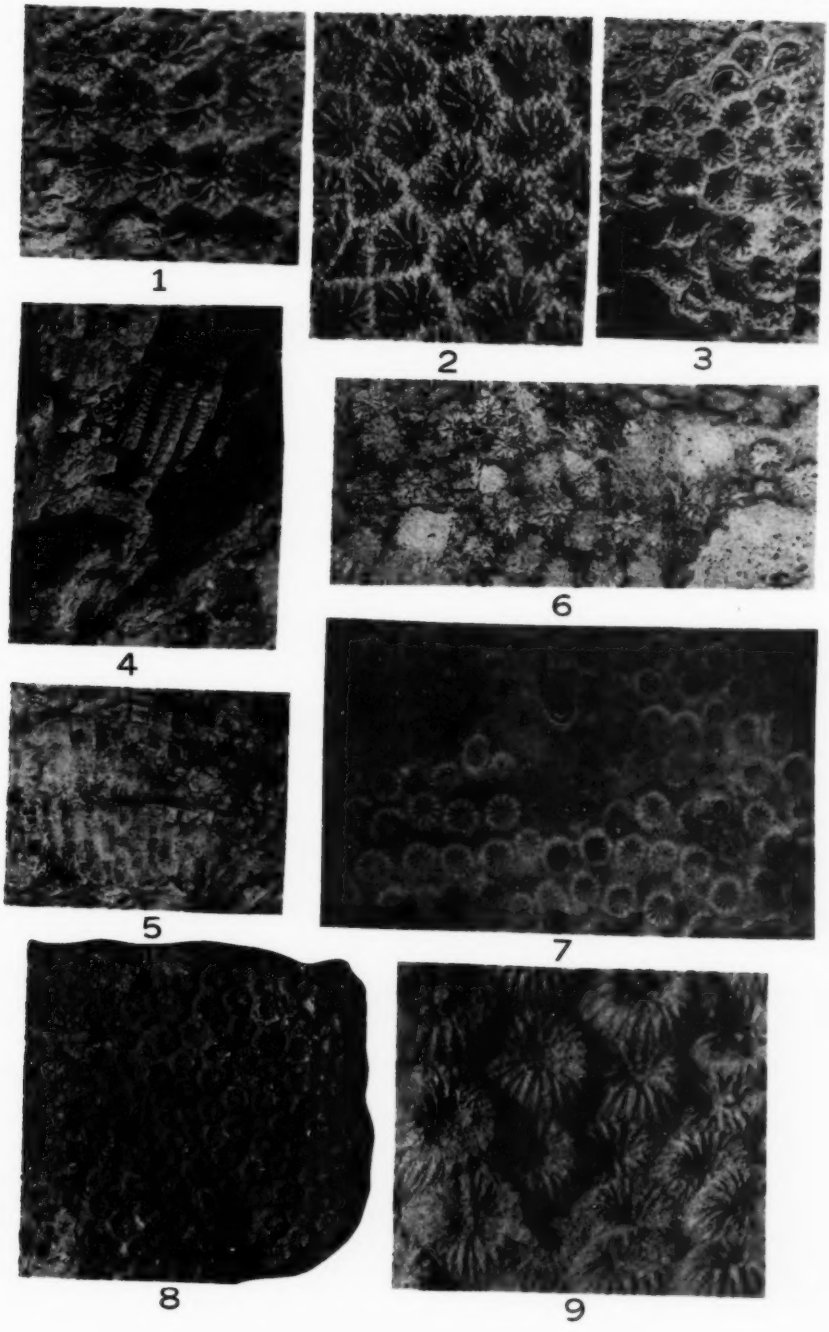
Occurrence. In the limestones of the *Arctica roemeri* beds about 200 feet above the base of the Glen Rose, on the Crane's Mill-Hancock road, Comal County; in the coral reef in the lower Glen Rose one mile above Pleasant Valley Crossing of Blanco River, Hays County.

[14] Felix, J., Anthozoën des Glandarienkalkes. *Beitr. z. Pal. u. Geol. O. U. u. d. Orients*, bd. 15, p. 179, pl. 17, fig. 7, 7a, 1903.

[15] Koby, F., *Polyp. jurass. de la Suisse*, p. 54, pl. 8, figs. 5, 6, 1886.

EXPLANATION OF PLATE 32

FIGS. 1,2—*Astrocoenia whitneyi* Wells, n. sp. 1, Calices of type specimen, ×4. 2, Calices of another specimen, ×4.
3—*Astrocoenia scyphoidea* Wells, n. sp. Calices of type specimen, ×4.
4—*Heterocoenia* (?) *hilli* Wells, n. sp. Cast of interior of corallum, ×4.
5—*Cyathophora haysensis* Wells, n. sp. Natural longitudinal section of type specimen, ×1.
6—*Orbicella whitneyi* Wells, n. sp., *var.* Calicular surface, ×2.
7—*Orbicella travisensis* Wells, n. sp. Worn calicular surface of type specimen, ×4.
8, 9—*Stephanocoenia* (?) *guadalupae* Wells, n. sp. 8, Corallum of type specimen, ×1. 9, Calices of type specimen, ×4.



Wells, Lower Cretaceous Corals

Genus STEPHANOCOENIA Edwards and Haime, 1848

STEPHANOCOENIA (?) GUADALUPAE Wells, n. sp.
Plate 32, figure 8, 9; Plate 39, figure 3

Description. The corallum is in the form of a massive, convex, rounded or subplane colony. The calices project above the intercorallite areas to a maximum height of 1.5 mm. around the edges of the corallum and to a height of less than 0.5 mm. in the interior. They are separated by a distance of 0.5–1.5 mm., are of medium depth and average 2.2 mm. in diameter within the walls. The septa are slightly exsert and join the costae over the low corallite wall. They are arranged in three complete cycles and six regular systems—a total of 24 septa. Their upper edges are faintly dentate or beaded and their sides somewhat granulate. On the inner upper edge of each of the primary and secondary septa, which are equal, is a relatively large tooth, evidently a palus. These twelve pali, or paliform teeth, form a crown around the columella in the bottom of the fossa. The septa of the third cycle are short and much thinner than those of the first two and extend less than a third of the distance to the columella. The costae are continuous with the septa over the walls and regularly alternate in size—the larger corresponding to the primary and secondary septa and the smaller to the tertiaries. Their upper edges are rounded and beaded with a single row of granules on each costa. The costae are not confluent between the calices but meet alternately midway. The columella is stout, projecting but a short distance into the calice, and appears to be a compressed axial style, often attached to one of the primary septa. Endothecal and exothecal dissepiments are well-developed, but can be made out only with difficulty in the specimens because of calcitization of the interior.

Remarks. There is some doubt whether the paliform teeth of this species represent true pali, and until this point can be determined, the generic reference must be questioned, although other characters of the genus *Stephanocoenia* are well marked in the Glen Rose specimens, which were compared with specimens of *S. intersepta* (Esper),[16] type species of the genus. Both species possess the same number of septa and pali arranged in the same manner within calices of nearly the same size. The main differences between the two forms are the projecting, boss-like calices and thick, rounded costae of *S.*(?) *guadalupae*. The calices of *S. intersepta* are shallow, not projecting much, although the strongly exsert septa give the appearance of considerable protrusion. The columella is usually styliform but cases were noted where it was much compressed and even attached to one of the principal septa. The costae of *S. intersepta* are thin, separated from each other by more than their own thickness.

S. formosa (Goldfuss),[17] a species of

[16] Vaughan, T. W., *U. S. Nat. Mus.*, Bull. 103, pp. 356–360, 1919.

[17] Goldfuss, A., *Petrefacta Germaniae*, 1, p. 111, pl. 38, fig. 9, 1826–33 Felix, J., *Palaeontographica* 49, p. 318, text fig. 59, 1903.

the European Senonian, possesses the same thick septa and costae, but the calices are much smaller and do not project and the septa and pali are fewer in number.

Occurrence. In the basal Glen Rose on Guadalupe River, below Demijohn Bend, Comal County.

Genus CONNECTASTREA Koby, 1904

CONNECTASTREA (?) INFUNDIBULIFORMIS Wells, n. sp.

Plate 33, figures 6, 7

Description. The corallum is in the form of a massive, convex, hemispherical colony, the type specimen measuring 170 mm. in diameter with a maximum height of 70 mm. The corallites are large, intimately united by a single wall formed by the close fusion of the separate corallite walls, polygonal in outline, with an average diameter of 8 mm. The calices are infundibuliform with a depth at the center of 2 mm. They are separated by thin ridges arising from the corallite walls. The septa are fairly thick, slightly exsert, from 12 to 18 in number. Their upper edges are badly worn in the single Glen Rose specimen so that the presence of granulations or denticulations cannot be ascertained. Toward the walls the upper edges of the septa are horizontal, but in the depression in the center of the calice they are concave. Septa of the first cycle extend to the center where they sometimes unite to form a pseudocolumella. Two of them may be stronger than the rest and fuse in the center, dividing the calice. The secondary and tertiary septa are obscure in the specimen and appear to extend but a short distance into the calice. The condition of preservation of the specimen makes it impossible to determine the character of the internal structure or the presence or absence of an epitheca.

Remarks. The genus *Connectastrea* was founded by Koby[18] to receive certain species which differed from *Amphiastraea* Étallon by the presence of a single intercorallite wall instead of independent corallite walls, resulting in massive astreiform colonies. The species which have been described up to the present time occur in the upper Jurassic, but it is not unlikely that the genus persisted into the lower Cretaceous. The present species resembles *C. piriformis* (Gregory),[19] type of the genus, from the upper Jurassic of India and Portugal, but differs in the larger size of the corallites.

[18] Koby, F., Polypiers du Jurassique supérieur. In Descr. de la faune jurass. du Portugal. *Com. du Serv. Géol. du Portugal.* p. 67, 1904.

[19] Gregory, J. W., Jurassic Fauna of Cutch. The Corals. *Palaeontologia Indica*, ser. 2, vol. 9, pt. 2, pp. 71–72, pl. 14, fig. 14, pl. 15, figs. 1, 2, 1900.

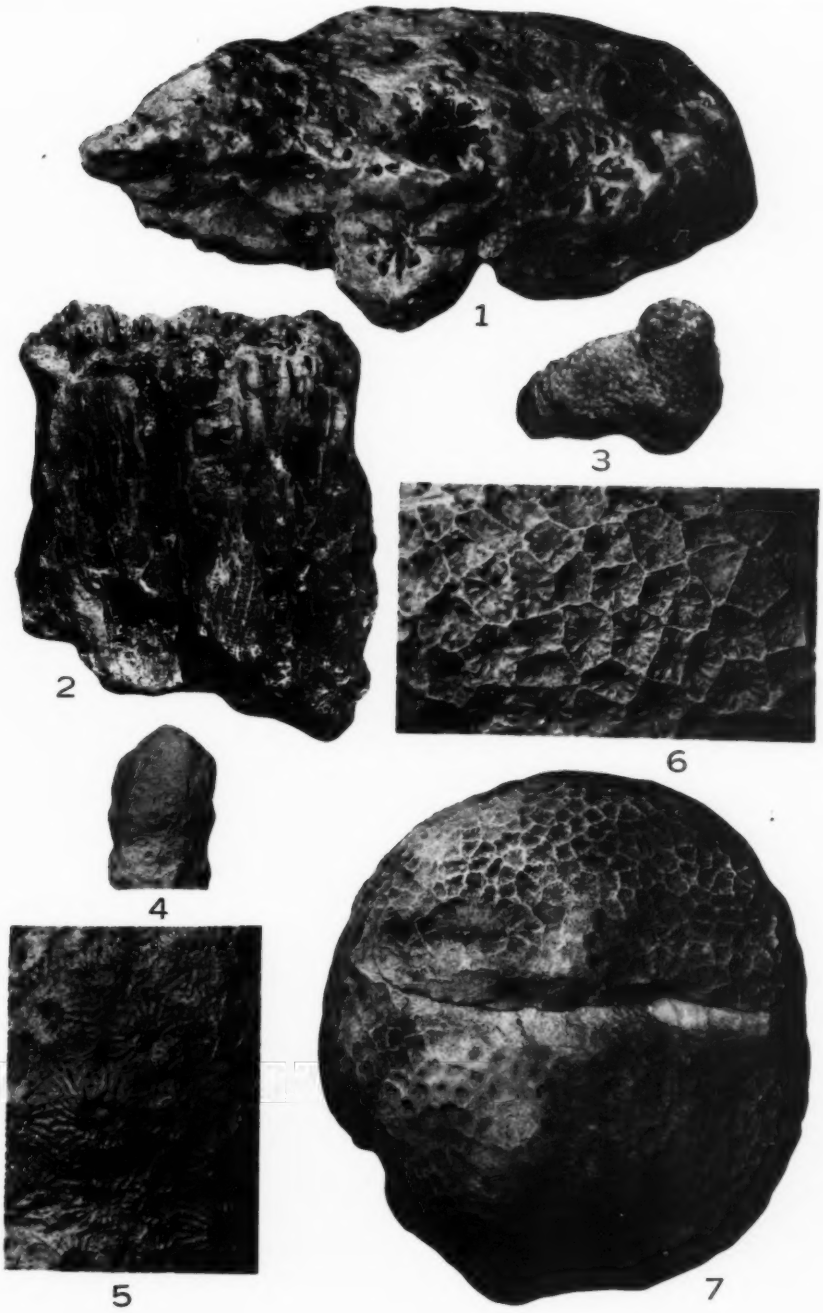
EXPLANATION OF PLATE 33.

FIGS. 1, 2—*Orbicella* (?) *comalensis* Wells, n.sp. 1, Calices of type specimen, ×1. 2, Lateral view of type, ×0.5.

3—*Astrocoenia scyphoidea* Wells, n. sp. Corallum of type specimen, ×1.

4, 5—*Cyathomorpha* (?) *damoni* Wells, n. sp. 4, Corallum of type specimen, ×1. 5, Calices of type specimen, ×4.

6, 7—*Connectastrea* (?) *infundibuliformis* Wells, n. sp. 6, Calices of type specimen, ×1. 7, Corallum of type specimen, ×0.4.



Wells, Lower Cretaceous Corals

Occurrence. In the uppermost Glen Rose near the top of a long hill on the New Braunfels-Crane's Mill road south of Suttler road, Comal County. This is the only species, represented by a single specimen, that has been found in the upper Glen Rose.

Genus CYATHOPHORA Michelin, 1843

CYATHOPHORA HAYSENSIS Wells, n. sp.
Plate 30, figure 4; Plate 32, figure 5

Description. The corallum is a massive convex colony, with cylindrical corallites circumscribed by thin, separate walls. The calices average 3.0 mm. in diameter, are slightly projecting, ribbed by costae, and spaced about 1.0 mm. apart. The septa are straight and unequal, numbering from 10 to 12. The primaries extend but halfway to the center, and the secondaries are rudimentary, forming ridges on the interior of the corallites. The interior of the corallites is partitioned off by transverse endothecal dissepiments after the manner of tabulae. Exothecal continuations of these dissepiments, which are never vesicular, extend between the corallites. In a space of 2 mm. there are four of these tabular dissepiments. There is no columella.

Remarks. Cyathophora atempa Felix[20] from the Neocomian of Mexico, differs from this species by having from 18 to 22 septa, smaller corallites spaced 2 mm. apart, and more abundant dissepiments (5 in 2 mm.).

Occurrence. In the coral reef in the lower Glen Rose one mile above Pleasant Valley Crossing, Blanco River, Hays County.

Genus EUGYRA de Fromentel, 1857

EUGYRA CUYLERI Wells, n. sp.
Plate 35, figure 4

Description. The colony is massive, subpedicellate, convex on the upper surface, a typical specimen measuring 200 mm. in diameter and 100 mm. in height. The corallites are directly united by their walls which produce ridges at the surface. The calices are confluent, forming meandroid or parallel series radiating from a central point on the upper surface. In the vicinity of this central point the series are definitely meandroid, but become parallel as they approach the edges of the corallum. They are narrow, averaging 2 mm. from wall to wall. The calicular centers are indistinct, but a section shows them to be about 5 mm. apart. The septa are strong, equal and entire, numbering from three to four within a space of 2 mm., and from six to nine being grouped about each calicular center. The dissepiments are tabular and parallel to the upper surface from three to four occupying a space of 2 mm. There is no columella.

Remarks. This species is related to *E. cotteaui* de Fromentel, a form widely distributed in the Neocomian of Europe and Africa and which has been reported from Mexico.[21] It may be distinguished from *E. cotteaui* by its equal rather than alternating septa.

Occurrence. Common in the reef

[20] Felix, J., *Palaeontographica*, bd. 37, p. 155, pl. 25, fig. 8, 1891.

[21] Felix, J., *Palaeontographica*, bd. 37, p. 159, 1891.

in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Family ORBICELLIDAE Vaughan

Genus ORBICELLA Dana, 1846

ORBICELLA TRAVISENSIS Wells, n. sp.
Plate 32, figure 7; Plate 38, figures 2, 3

Description. The corallum is a small, convex or subglobose colony. All of the specimens found have been rolled or worn before fossilization and do not show the features of the exterior. The corallites are cylindrical, averaging 2.0 mm. in diameter within the walls, separated by intercorallite areas 1.0–0.2 mm. in width. They are bounded by a thick wall ribbed by costae corresponding to the septa. The calices, as revealed in a small area on the type specimen, are circular, shallow, and but slightly projecting, with a diameter within the walls of 1.5 mm. The septa are 24 in number, arranged in three cycles and six regular systems, straight, unequal, slightly denticulate on their upper edges and strongly granulated laterally. The septa of the first and second cycles are strong and equal, extending to the columella, to which they are joined. The septa of the third cycle are thin and rarely extend more than a third of the distance to the columella. In longitudinal sections the inner edges are notched, and the septa of the last cycle appear to be slightly perforate. The costae, as seen in cross-section, are equal, short, and stout, rarely uniting between the corallites, but where they appear on the surface they extend over most of the intercorallite space. The columella is trabecular and well-developed, united to the ends of the septa by processes. When viewed in cross-section it appears to be formed of several vertical pillars, but in a longitudinal section these pillars are seen to consist of interlacing rods. The endothecal dissepiments are delicate, thin, sparse, horizontally disposed. The exothecal dissepiments are much thicker, more abundant, nearly horizontal, inclined downward from the corallite walls, numbering about six in a space of 5 mm. Where they unite midway between the corallites there is a vertical series of thin dissepimental tissue.

Remarks. This species, when first seen in section, might be mistaken for some species of *Columnastrea*, but the lack of pali and the structure of the columella indicate a nearer relationship to *Orbicella*. It groups with *O. annularis* (Ellis and Solander),[22] type species of the genus, and other species with small corallites and three cycles of septa, including the later described *O. whitneyi*. *O.*(?) *texana* Vaughan,[23]

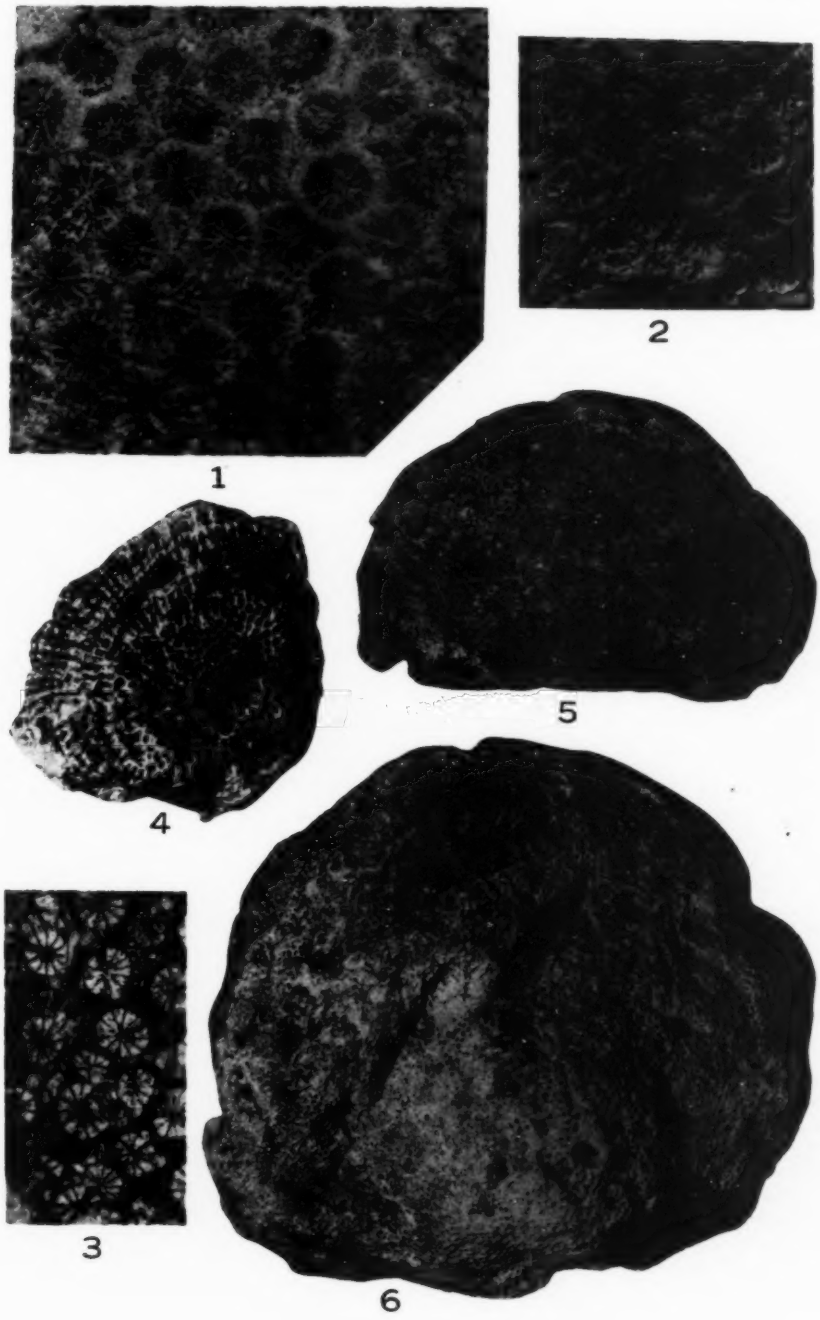
[22] Vaughan, T. W., *U. S. Nat. Mus.*, Bull. 103, pp. 364–375, pls. 80–84, 1919.

[23] Vaughan, T. W., *U. S. Geol. Survey*, Bull. 205, 1903.

EXPLANATION OF PLATE 34

FIGS. 1, 5—*Orbicella whitneyi* Wells, n. sp., *var.* 1, Worn calices, ×4. 5, Corallum of same specimen ×0.5.

2–4, 6—*Orbicella whitneyi* Wells, n. sp., typical. 2, Calices of type specimen, ×4. 3, Natural mold of calices, ×4. 4, Worn corallum from basal Glen Rose, ×0.5. 6, Corallum of type specimen, ×0.5.



Wells, Lower Cretaceous Corals

from the Buda limestone in Texas, is distinguished from the Trinity species by possessing only 20 septa, 10 of which are large and extend to the columella.

There are several undescribed species of *Orbicella* from horizons between the Glen Rose and the Buda limestone, none of which, however, appear to be closely related to either *O. travisensis* or *O. whitneyi*.

Occurrence. In the Travis Peak formation at the following localities: on Cow Creek about one mile below Travis Peak Post Office, Travis County; about five miles west of Cox's Crossing, on the Austin-Marble Falls road, Burnet County.

ORBICELLA WHITNEYI Wells, n. sp.
Plate 34, figures 1–6; Plate 38, figure 1

Description. The corallum is in the form of a massive, irregularly hemispherical or subglobose, colony. The type specimen measures 180 mm. in diameter with a maximum height of 85 mm. and much larger, loose, weathered masses are common in the lower Glen Rose reefs. The corallites are cylindrical, projecting, possessed of thick walls, united by dissepiments, and have an average diameter within walls of 1.2 mm. Between them are spaces of about 0.3 mm. in extent. The calices are regularly disposed over the surface of the colony and are crateriform, circular, averaging 0.75 mm. in height, from 0.75 to 1.0 mm. in diameter, and separated by an average distance of 1.0 mm. The septa number 24 and are moderately thick, straight, spinulose laterally, beaded on their upper edges, arranged in three cycles and six regular systems. Those of the first and second cycles are equal in length and thickness and extend to the columella. The tertiaries are short and extend inward but a short distance from the wall. The costae are continuous with the septa over the calicular walls which they wholly conceal, and are not confluent in the intercorallite spaces. Their upper edges are rounded and lightly beaded. Internally, when seen in cross-section, they are not confluent but form rounded ridges with heights corresponding to the cycle of the septa which they represent, those of the first cycle being the largest. The columella is spongy and not well developed, not prominent in the calices. The endothecal dissepiments are sparse whereas the exothecal dissepiments are thick and numerous. Increase is by intracalicular gemmation.

Remarks. Although specimens of this species are relatively common, they are never well preserved and few show the essential features, even the type specimen having very few unworn calices. The internal structure has been determined from sections from the paratypes.

O. travisensis closely resembles this species but possesses a slightly larger calice, a thicker corallite wall and a columella of interlacing processes appearing papillose on the surface.

The specimen shown on Plate 34, figures 1, 5, probably represents a growth facies of *O. whitneyi*. It is marked by its more regularly hemispherical form and slightly larger corallites which average 1.6 mm. in

diameter and 2.5 mm. between centers.

One badly preserved specimen (pl. 32, fig. 6) from the reef at Pleasant Valley Crossing will probably prove to be a distinct variety of the species. It is distinguished by corallites 2.0 mm. in diameter separated by a distance of 1.0 mm. The columella consists of a few trabecular expansions of the septa and occasionally appears as a thin irregular lamella.

Occurrence. The type specimen comes from the massive beds of the lower Glen Rose, 20 feet above the Guadalupe River, three miles below Crane's Mill Crossing, Comal County. Other specimens come from the basal Glen Rose localities near Spring Branch, Comal County.

Plate 34, figure 4 shows a typical specimen from the basal beds in which all structural details have been destroyed, leaving a porous mass of granular brown and white limestone.

It is also occasionally found in the reefs at the Narrows of Blanco River, Blanco County, and on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

ORBICELLA (?) COMALENSIS Wells, n. sp.
Plate 33, figures 1,2

Description. The corallum is in the form of a tall, massive colony. The corallites are cylindrical, bounded by a thick wall, and united by exotheca. The calices are circular, close-set, crateriform, and slightly elevated, with an average diameter of 12 mm. The septa are of medium thickness, not very exsert, 18 in number. The arrangement is irregular, with nine principal septa, stronger than the rest, extending to the columella. The remaining septa are thin and reach about halfway. The endothecal dissepiments are numerous, tabulate in the center of the corallite near the weak columella, and ascending and becoming vertical in the peripheral area, spaced about 1 mm. apart. The exotheca is thick and stout.

Remarks. The only specimen of this species is a much-worn fragment from the lower Glen Rose. None of the finer details of the corallum can be made out and the generic reference is only tentative. It is readily distinguished from *O. travisensis* and *O. whitneyi* by the much greater size of the corallites.

Occurrence. In the lower Glen Rose on the Fischer's Store road, three miles from Hancock, Comal County.

Family FAVIIDAE Gregory

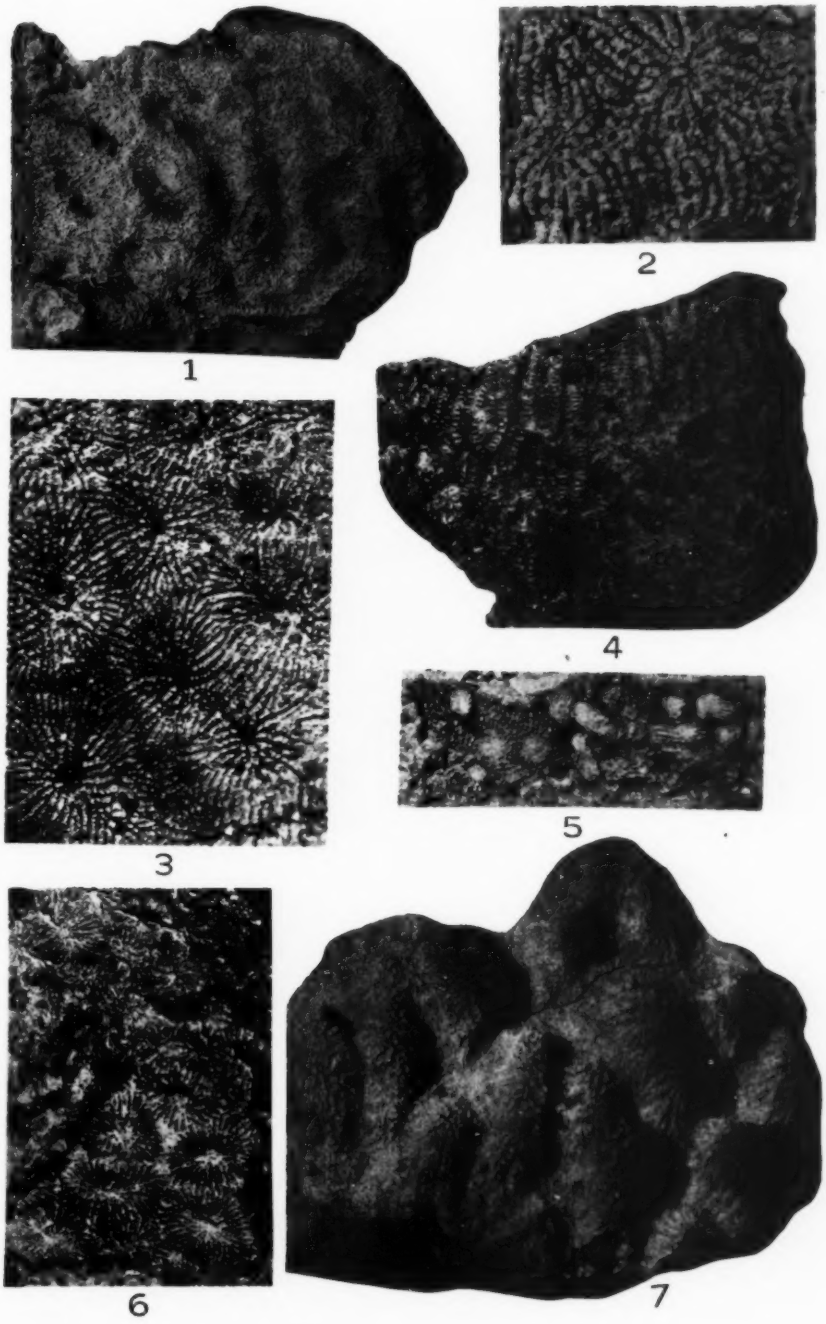
Genus THECOSMILIA Edwards and Haime, 1848 (emend. Frech, 1890)

THECOSMILIA (?) sp.
Plate 30, figure 3

Description. The corallum forms branching clumps of which the in-

EXPLANATION OF PLATE 35

FIGS. 1—*Meandraraea plummeri* Wells, n. sp. Calicular surface of type specimen, ×1.
2—*Microsolena texana* Wells, n. sp. Weathered natural section of corallites, ×2.
3—*Siderofungia irregularis* Felix. Calices of typical Glen Rose specimen, ×4.
4—*Eugyra cuyleri* Wells, n. sp. Calicular surface of type specimen, ×1.
5—*Polytremacis* (?) *hancockensis* Wells, n. sp. Mold of surface of type specimen, ×1.
6—*Complexastrea* (?) *glenrosensis* Wells, n. sp. Calices of type specimen, ×2.
7—*Hydnophora* (?) *blancoensis* Wells, n. sp. Worn surface of type specimen, ×4.



Wells, Lower Cretaceous Corals

dividual corallites are subcylindrical and roughly circular in cross-section, measuring about 15 mm. in diameter. The specimens have been worn before fossilization and show neither the wall or outer surface. The interior is better preserved and shows about 60 septa, of which about 30 are thick and extend to the center, where they sometimes meet. The remainder are thin and reach about halfway. The endothecal dissepiments are well-developed and in some specimens reach to the center of the corallite. Increase is by fissiparity. Epitheca not preserved.

Remarks. The specimens doubtfully referred to this genus occur as calcitized fragments in a matrix of chalky limestone and have been so crushed and distorted by pressure and riddled by boring molluscs that a specific characterization is impracticable at present, although undoubtedly a new species is involved.

Examples of this species cannot be shown well in a photograph and a diagram of a cross-section of a typical corallite has been used to illustrate the internal structure.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Genus BLOTHROCYATHUS Wells, n. gen.

Description. Corallum simple, large, attached at the base, tall and cylindrical, straight, slightly curved, or contorted, covered with a thick, noncostate epitheca which is coalescent with the thin theca. The septa are relatively few in number, considering the large size of the mature individuals, lamellar, thick, well-developed, radially arranged, and lightly but thickly granulated laterally. The interseptal loculi are partitioned centrally by tabular dissepiments which are arched downward toward the center, and peripherally by outwardly arching, becoming almost vertical near the tabulate zone, ascending, vesicular dissepiments, which may form a false inner wall where they meet the tabulae. There is no true columella although the inner ends of the principal septa may meet to form a feeble parietal axis.

Remarks. The three specimens upon which the preceding description is based show the internal structure, and in some measure, the outer features of the corallum, but in none of them is the calice preserved nor can the character of the upper margins of the septa—whether dentated, beaded, or smooth—be determined. The finer structure of the septa has been obliterated by calcitization, although a thin transverse section of a septum usually shows a dark median line which is more or less regularly interrupted, which may indicate that the upper margins of the septa may be dentate, as in *Montlivaltia*, although the trabecular structure is too obscure for definite proof. The septa are much thickened by the addition of successive layers, loosely applied in the character of dissepiments, giving them a wedge-shaped section, decreasing in thickness toward the center and producing at

first a thick wall, as is the case in many of the Tetracoralla.[24]

Although it is related possibly to earlier forms elsewhere, the lone position of *Blothrocyathus* among the other American Mesozoic corals makes it difficult to see its affinities.

Many of the structural features are reminiscent of the later Paleozoic cyathophyllids: the radial arrangement of the septa, the central tabulate zone, and the broad outer zone of vesicular dissepiments. In these broader characters it is also similar to the Mesozoic genera *Thecosmilia* E. and H. and *Montlivaltia* Lamouroux, and for the present it is associated with the former genus until more details of the septal structure can be determined. Two of the species described by Frech[25] from the European Triassic, *T. fenestrata* Reuss and *T. cyathophylloides* Frech, in particular, show an internal structure similar to that of the Glen Rose form, but the central tabulate and peripheral vesicular zones are not as well-defined. Species of both *Thecosmilia* and *Montlivaltia* possess a more or less thick, but easily eroded epitheca, and a relatively large number of septa.

The type species is *B. harrisi* Wells, n. sp., from the lower Glen Rose.

[24] Grabau, A. W., *Pal. Sinica*, ser. B, vol. ii, fasc. i, p. 14–15, 1922.

[25] Frech, F., *Palaeontographica*, bd. 37, p. 9, pl. 2, fig. 10a; p. 12, pl. 3, fig. 6b, 1890.

BLOTHROCYATHUS HARRISI Wells, n. sp.
Plate 30, figures 6, 6a, 7; Plate 31, figures 3, 4

Description. Characters as of the genus described above. The corallum is simple, cylindrical, attaining considerable height, straight or slightly curved and distorted, consisting, when mature, of a series of expansions and contractions which resemble the invaginated cup structure often found in species of *Cystiphyllum*, although the invagination is not reflected by the interior structure. In the smaller specimen these irregularities are not as striking. The dimensions of the three specimens mentioned in the generic description are as follows:

DIMENSIONS

	Holotype	*Paratypes*	
	mm.	mm.	mm.
Length of corallum..	335	100	40
Average diameter...	50	12–22	65

The holotype is the most complete specimen, lacking a small portion near the base and another near the calice. Its total length was originally around 400 mm., unusually large for the simple corals of the Mesozoic. The first paratype is a small contorted fragment and does not present the full complement of septa that is found in the mature form. The second paratype is a small part of a very large corallum which was considerably distorted.

The exterior of the corallum is

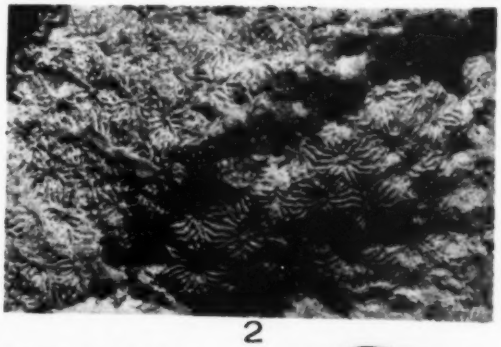
EXPLANATION OF PLATE 36

FIGS. 1–3—*Centrastrea vaughani* Wells, n. sp. 1, Natural transverse section, of corallites, ×4. 2, Calices of type specimen, ×4. 3, Globose corallum, ×0.5.

4, 5—*Polyphyllastrea simondsi* Wells, n. sp. 4, Calicular surface of type specimen, ×1. 5, Calices of type, ×4.

6—*Astreopora* (?) *leightoni* Wells, n. sp. Mold of surface of type, ×4.

1



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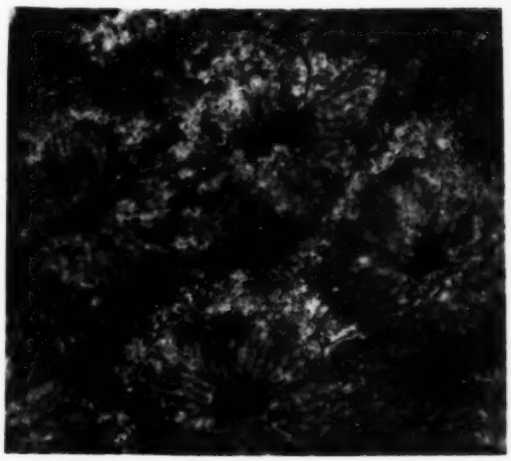
4

3



5

6

Wells, Lower Cretaceous Corals

covered by a thick epitheca which forms part of the wall and is marked only by fine concentric lines of growth. On the interior there are three complete cycles of septa in the mature form, two in the younger, arranged in six regular systems. The septa of the first cycle are slightly longer than those of the second and extend to the center, sometimes uniting. Those of the second cycle have about the same thickness and their tapering inner ends are produced nearly to the center. The septa of the last cycle are thick and wedge-shaped, about one-third as long as the others. The granulations on the sides of the septa number about five in a space of 1 mm. The tabular dissepiments occupying the central area are depressed in the center and vertically spaced about 1 mm. apart. The peripheral dissepiments are well developed, greatly thickened, as are also the septa, by the addition of successive layers, ascending, outwardly arched, anastomosing to form nearly vertical cells in the interseptal loculi and forming a poorly defined false inner wall where they meet the tabular dissepiments. No columella.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River one mile above Pleasant Valley Crossing, Hays County.

Genus HYDNOPHORA Fischer de Waldheim, 1807

HYDNOPHORA (?) BLANCOENSIS Wells, n. sp.
Plate 35, figure 7

Description. The corallum forms an encrusting colony. The corallites are in series, united by their walls, the continuity of which is more or less regularly broken to form ovate rounded collines from 3 to 4 mm. in length and about 2 mm. in height. The septa are relatively thick, equal, bifurcated at their inner ends, three of them occupying the space of 1 mm. No columella.

Remarks. The single specimen of this species now known from the Glen Rose is a small fragment measuring 15 by 20 mm., so poorly preserved that the finer details of the structure are quite indiscernible. It is referred to the genus *Hydnophora* on the basis of the interrupted collines and bifurcated septa, although it is likely that it will ultimately prove to be a fungid coral.

Compared with *H. styriaca* Reuss,[26] the common European Senonian form, the present species is much larger in every way and possesses relatively fewer septa, more nearly approaching some of the recent species of the genus.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Suborder MADREPORARIA FUNGIDA Duncan

Family AGARICIIDAE Verrill

Genus SIDERASTREA de Blainville, 1830

SIDERASTREA CUYLERI Wells, n. sp.
Plate 37, figure 9; Plate 39, figure 1

Description. The corallum forms a massive, probably convex, colony.

[26] Felix, J., *Palaeontographica*, bd. 49, 1903.

The corallites are distinctly subhexagonal in outline and are directly united by their walls which are thin and irregular. The calices are of medium depth (?), with an average diameter of 3.5 mm. within the walls, for the mature corallites. The septa number from 24 to 36, and are imperforate, straight or slightly curved, nearly equal in thickness, and finely granulated or spinulose on their sides. Their upper edges cannot be seen in any of the specimens now at hand, but from the structure of the trabeculae as seen in longitudinal sections they are presumed to be beaded with prominent inner teeth. The septa of the third and fourth cycles, when they are developed, are fused to those of the preceding cycle. From 8 to 12 of the principal septa are fused to the columella. The synapticulae are well-developed in two rows near the wall and tend to fill up the interseptal loculi in that region. The columella is composed of 3 or 4 fused papillae. The exterior of the corallum is not shown by any of the specimens.

Remarks. This appears to be the first representative of this well-known Tertiary and Recent genus to be found in the Comanchean. Its nearest affinities appear to be with the group of species of *Siderastrea* marked by the presence of an incomplete fourth cycle of septa,[27] and is nearest to *S. radians*, type of the genus, although lack of any specimens of *S. cuyleri* which show the exterior of the corallum makes the comparison unsatisfactory in spite of the close agreement of the internal structure.

Occurrence. In the Travis Peak formation on Cow Creek, about one mile below Travis Peak Post Office, Travis County; and about five miles west of Cox's Crossing on the Marble Falls-Austin road, Burnet County.

Genus ISASTREA Edwards and Haime, 1851

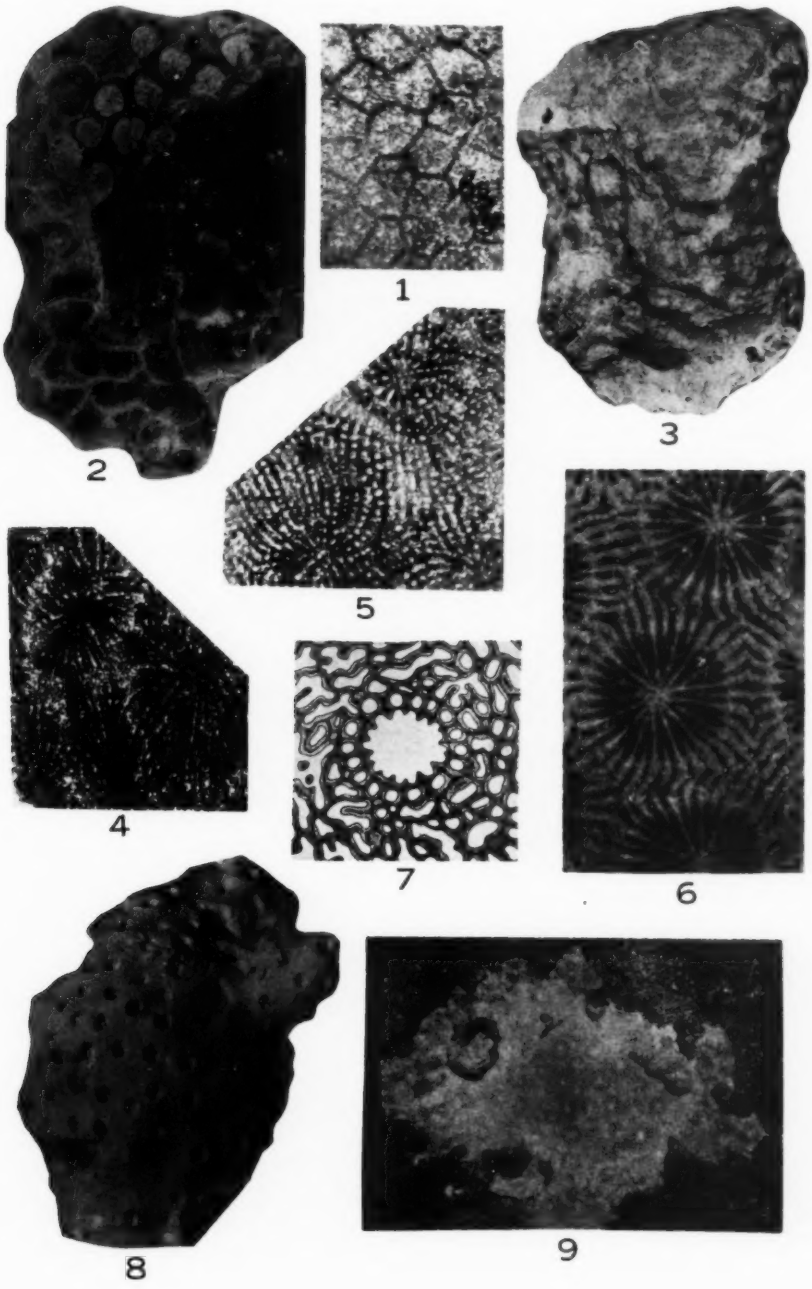
Gregory[28] made a careful comparison of *Isastrea* and *Thamnasteria* and came to the conclusion that the only point of distinction between them lay in the somewhat different arrangement of the dissepiments in the two genera. Nevertheless, in spite of the fact that *Isastrea* possesses the same fungid characters found in *Thamnasteria*—primarily the synapticulae and lamellar septa—he retained *Isastrea* as an "astreid" and placed *Thamnasteria* among the fungids. It must be noted, however, that

[27] Vaughan, T. W., *U. S. Nat. Mus.*, Bull. 103, p. 437 ff., 1919

[28] Gregory, J. W., *Palaeontologia Indica*, ser. 9, vol. 2, pt. 2, p. 123–125, 1900.

EXPLANATION OF PLATE 37

FIGS. 1—*Astrocoenia whitneyi* Wells, n. sp. Transverse section, ×4.
2—*Comalia fasciculata* n. gen., n. sp. Polished surface of type specimen, ×4.
3—*Meandraraea* sp. cf. *M. tulae* (Felix). Worn corallum, ×1.
4—*Dimorpharaea* sp. cf. *D. barcenai* (Felix). Diagonal section of corallum, ×2.
5—*Microsolena texana* Wells, n. sp. Transverse section, ×2.
6—*Diploastrea harrisi* Wells, h. sp. Transverse polished section, ×4.
7—*Epiphaxum vermiculata* Felix. Transverse section of corallite to show structure, ×10. (From Felix, 1903, textf. 67.)
8—*Epiphaxum labyrinthica* Wells, n. sp. Corallum of type specimen, ×4.
9—*Siderastrea cuyleri* Wells, n. sp. Polished surface of type specimen, ×1.



Wells, Lower Cretaceous Corals

Gregory's conclusions regarding *Isastrea* were not based upon a study of the type species of the genus, *Astraea helianthoides* Goldfuss,[29] and until such a study is made the status of the genus remains uncertain.

ISASTREA WHITNEYI Wells, n. sp.
Plate 39, figures 4, 5

Description. The corallum forms an irregularly convex, tall, massive colony. The corallites are polygonal in outline, very variable in shape, separated by a thin, well developed synapticular wall, on the upper edges of which the septa meet, forming obtuse ridges. In some cases the wall is not straight, but zig-zag in plan. The calices are shallow and broad, measuring from 2.5 to 5.0 mm. in the same corallum. The septa are from 30 to 45 in number, imperforate, straight, thin, equal, and somewhat irregular in their cyclical arrangement. The septa of the first cycle usually extend to the center where they unite with the trabecular columella. The secondary septa are nearly as long as the primaries and to them are fused the inner ends of the remaining cycles—the third and part of the fourth. Their upper edges are lightly beaded and the sides are provided with rows of spinulose granulations extending upwards and outwards. Near the wall is a single ring of synapticulae, often not well developed and rarely seen in the specimens. The dissepiments are not abundant and are much finer than the synapticulae. Increase is by fissiparity.

Remarks. The fungid nature of this species is apparent, as is also the similarity between the genus represented by it and *Siderastrea*.

It closely resembles *I. serialis* E. and H. from the upper Dogger of Monte Pastello near Verona, specimens of which were examined in the National Museum and which possessed synapticulae, the chief differences between the two being in the fewer septa and slightly smaller calices of the Glen Rose species.

Occurrence. This species is common at many localities in the lower Glen Rose, being especially abundant in the basal beds at Spring Branch, on the New Braunfels-Blanco highway beyond the fork to Spring Branch, Comal County. It is also found at an horizon 180 feet above the base of the Glen Rose in a road cut west of Esser's Crossing of Guadalupe River, Comal County; in the coral reef in the lower Glen Rose at the Narrows of Blanco River, Blanco County; and in the reef on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Genus COMPLEXASTREA d'Orbigny, 1849

Gregory[30] pointed out that *Complexastrea* is the correct name for the *Confusastrea* of many authors. Specimens of *C. burgundiae* (Leymerie), from the upper Jurassic, stated by Gregory to be the type species of the genus, in the United States National Museum are unquestionably fungid corals related to *Isastrea* and possibly to the *Oulastreids*. On the

[29] Goldfuss, *Petrefacta Germaniae*, p. 65, pl 22, fig 4a (non 4b), 1827.

[30] Gregory, J. W., *Pal. Indica*, ser. 9, vol. ii, pt. 2, p. 119, 1900.

strength of this fact, the species described below is doubtfully placed in the genus. The main point of distinction between this genus and the *Oulastreid* group is in the fissiparous mode of increase of the former.

COMPLEXASTREA (?) GLENROSENSIS
Wells, n. sp.
Plate 35, figure 6; Plate 38, figure 4

Description. The corallum forms lobed, subplane, or concave masses increasing by fissiparity, bounded by a strongly costulated common wall and fixed by a narrow base. The calices are rounded or elliptical, irregular and unequal, usually slightly projecting and separated by narrow depressions, with low rounded margins. They are frequently elongated and deformed by division, and in some places may be closely set to the exclusion of the intercorallite depressions. The rounded calices average 4 mm. in diameter and the elliptical ones average 6 mm. on the longer diameter and 3.5 mm. on the shorter. They usually project less than 1 mm. above the surface and the average distance between them is 1 mm. The calicular fossa is of medium depth, averaging 1.5 mm. The septa are not definitely arranged in cycles and number from 22 to 30, rarely more in the elongate calices. They are equal, thick, straight, perforate on their inner margins, strongly beaded on the upper edges, the granulations increasing in size toward the columella. They are united by a few poorly developed synapticulae, which occasionally form a weak corallite wall. The septo-costae, slightly less beaded than the septa, are confluent between the corallites and correspond to the septa. The columella is well-developed, trabecular, papillose on its upper surface and fused to the inner ends of the principal septa, not projecting much into the calice. Dissepiments and epitheca have not been observed.

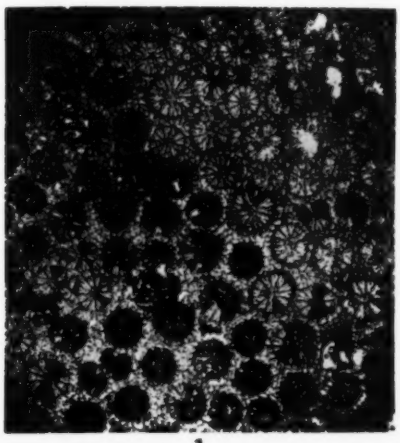
Remarks. This species is distinguished from other species of the genus by the relatively small size of the corallites. In outward appearance it is very much like several of the upper Jurassic species of *Favia* described by Koby,[31] *F. plicata* Koby, *F. dendroidea* Koby, and *F. michelini* E. and H. Koby has given no details of the internal structure of these species and it is not unlikely that they will prove to be fungids.

Occurrence. In the coral reef on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

[31] Koby, F., *Polypiers du Jurass. sup. du Portugal*, pp. 90–97, pls. 10–11, 1904.

EXPLANATION OF PLATE 38

FIGS. 1—*Orbicella whitneyi* Wells, n. sp. Transverse section, ×3.
2, 3—*Orbicella travisensis* Wells, n. sp. 2, Transverse section, ×. 3, Longitudinal section, ×3.
4—*Complexastrea* (?) *glenrosensis* Wells, n. sp. Transverse section, ×3.
5, 6—*Diploastrea harrisi* Wells, n. sp. 5, Transverse section, ×3. 6, Longitudinal section, ×3.



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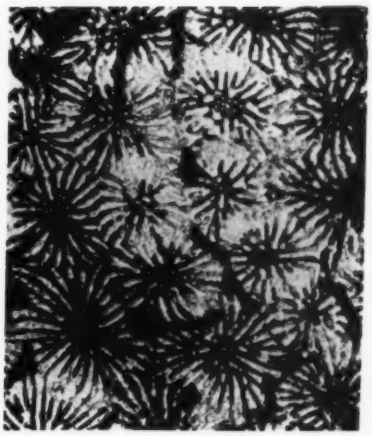

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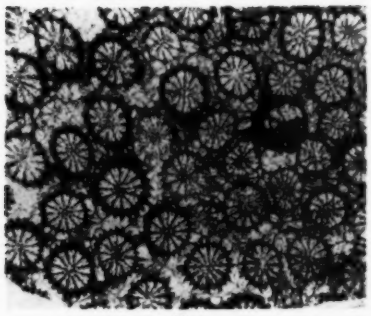

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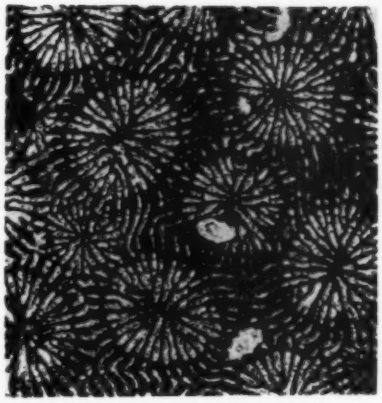

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Wells, Lower Cretaceous Corals

Genus CENTRASTREA d'Orbigny, 1849

CENTRASTREA VAUGHANI Wells, n. sp.
Plate 36, figures 1, 2, 3

Description. The corallum forms a laminated, irregularly convex or foliaceous colony, often becoming digitate or globose, covered on the common plateau by a very thin, easily eroded, wrinkled epitheca. The corallites are short, irregularly spaced and united directly by septo-costae. The calices are small and shallow, the distance between centers varying from 1 to 2 mm. The septa are lamellar, thick, equal, straight within the corallite, beaded on their upper edges and sides. They number from 16 to 24, of which 10 to 14 extend to the center and join the columella. Synapticulae are present, but are not abundant and are usually rendered indistinct by fossilization. The columella is styliform and forms a prominent knob in the calice with its upper surface depressed slightly below the level of the septa.

Remarks. The wide variation in specimens of this species is shown by the following measurements of three typical specimens:

	DIMENSIONS	
Specimen	*Number of septa*	*Distance between centers*
1	17	1.5 mm.
2	21	1.1 mm.
3	24	1.9 mm.

Specimens 1 and 3 are from the basal beds of the Glen Rose; 2 is from an horizon near the middle of the same formation. Specimens of the foliaceous form of this species come from the basal beds and those of the digitate types occur in the reef near Pleasant Valley Crossing. The holotype represents one of the foliaceous forms from the basal beds, while the digitate and globose forms may form varieties distinguished by the form of the corallum and size of the calices.

The presence of the styliform columella removes this species from the genus *Thamnasteria* (*Thamnastraea* auct.) as defined by Edwards and Haime[32] to the genus *Centrastrea* d'Orbigny.[33]

The globose form of this species noted above is very close to *C. urgonensis* Koby[34] of the Swiss Urgonian except for the calices, which are slightly larger than in Koby's species.

Occurrence. In the basal Glen Rose on the New Braunfels-Blanco road beyond the road to Spring Branch, and on Guadalupe River below Demijohn Bend, Comal County. In the reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Family OULASTREIDAE Vaughan

Genus CYATHOMORPHA Reuss, 1868

CYATHOMORPHA (?) DAMONI Wells, n. sp.
Plate 33, figures 4, 5

Description. The colony is subdendroid, with short, thick branches formed by elongated extensions of the upper surface of the corallum, encrusting in its earlier stages, covered on the sides and lower surface by a wrinkled epitheca. The corallites

[32] Edwards and Haime, *Hist. nat. des Coral.*, vol. 2, p. 555, 1857.

[33] d'Orbigny, A., *Note sur des polyp. foss.*, p. 9, 1849. Also Gregory, J. W., *Palaeontologia Indica*, ser. 9, vol. 2, pt. 2, p. 140, 1900.

[34] Koby, F., *Polypiers crétacés de la Suisse*, p. 82, pl. 19, figs. 4–8; pl. 20, figs. 1, 2, 1897.

are short, slightly protuberant, cylindrical, averaging 1.8 mm. in diameter in cross section, united by septo-costae, with a poorly developed synapticular wall. The calices are shallow, circular in outline with an average diameter of 1.4 mm., irregularly spaced from 3.5 to 5.0 mm. apart. The septa vary in number from 24 to 30 and are continuous with the septo-costae, denticulate on their upper edges, spinulose laterally, thick and equal peripherally, becoming thinner as they approach the columella. In a calice with three complete cycles of septa, the septa of the first two cycles are equal, united to the columella, and bear thick paliform lobes which are nearly one-half the width of the septa. The remaining septa of the third cycle are thin, shorter than the others, and free at their inner ends. The columella is small, trabecular, appearing in the calice as one or two large papillae, sometimes compressed and lamelliform. The septo-costae, which are confluent between corallites are thick and rounded on their upper edges, covered by numerous, small, rounded granulations. The synapticulae appear to be poorly developed, as are the dissepiments, but this condition is probably due to the conditions of preservation.

Remarks. The specimens upon which the foregoing description is based show the external features well but in every case the interiors are completely filled with granular calcite and all structure is practically obliterated.

This species possesses all the essential characters of *Cyathomorpha*[35] but does not resemble any of the species now known. Its nearest affinities will probably be found among some of the Cretaceous species of fungids which are at present placed in *Orbicella*, *Favia*, *Phyllocoenia*, etc.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Genus DIPLOASTREA Matthai, 1914

DIPLOASTREA HARRISI Wells, n. sp.

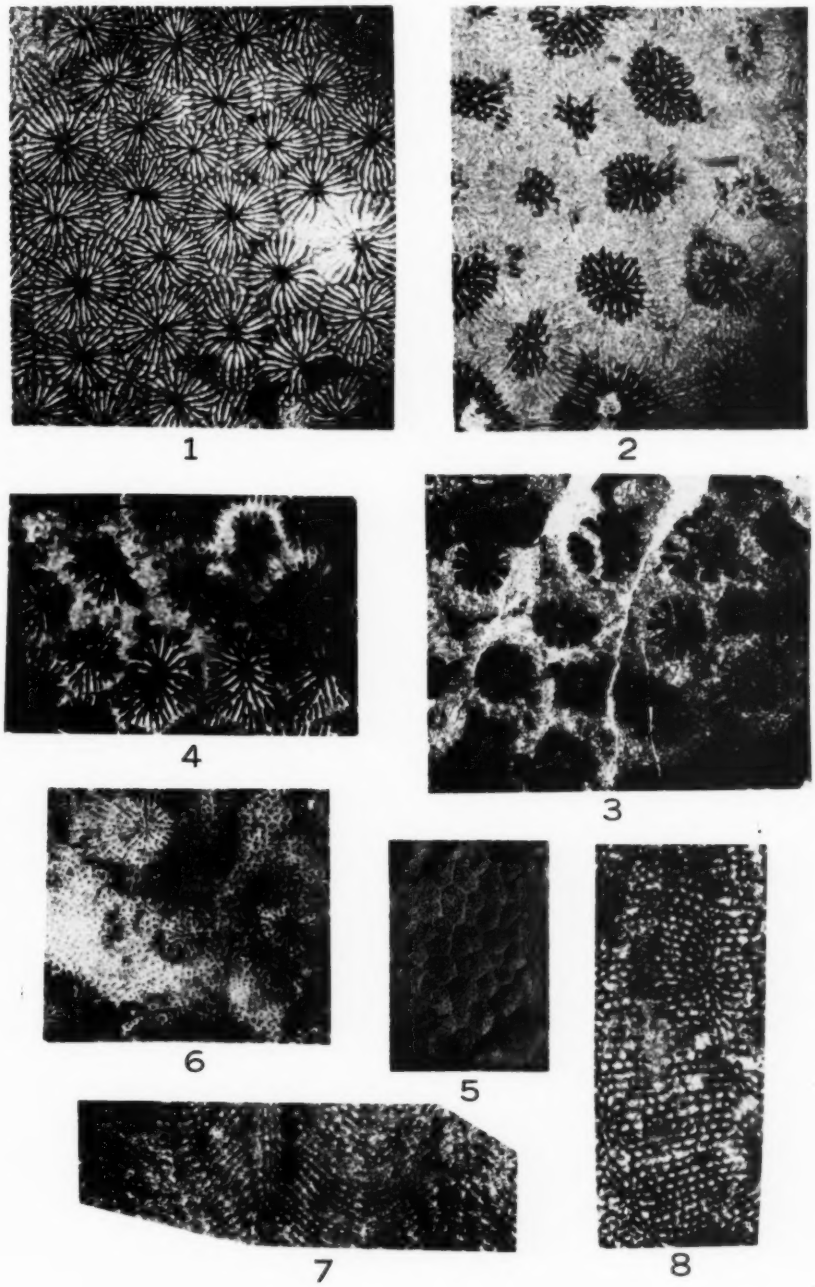
Plate 30, figure 9; Plate 37, figure 6; Plate 38, figures 5, 6

Description. The corallum is in the form of a massive, convex or hemispherical colony, attaining a diameter of 50 cm. or more. The corallites are tall, cylindrical, bounded by a poorly defined synapticular wall. The calices are not preserved in any of the specimens yet collected, but a transverse section near the tops of

[35] Vaughan, T. W., *U. S. Nat. Mus.*, Bull. 103, p. 456, 1919.

EXPLANATION OF PLATE 39

FIGS. 1—*Siderastrea cuyleri* Wells, n. sp. Transverse thin-section, ×3.
2—*Siderofungia irregularis* Felix. Transverse thin-section, ×3.
3—*Stephanocoenia* (?) *guadalupae* Wells, n. sp. Transverse thin-section, ×3.
4, 5—*Isastrea whitneyi* Wells, n. sp. 4, Transverse thin-section, ×3. 5, Calices of the type specimen, ×1.
6—*Polyphyllastrea simondsi* Wells, n. sp. Polished transverse section, ×2.
7, 8—*Meandraraea plummeri* Wells, n. sp. 7, Longitudinal thin-section across collines, ×2. 8, Transverse section of calicular series, ×2.



Wells, Lower Cretaceous Corals

the corallites gives an average diameter within the walls of 4 mm. and a distance of from 6 to 7 mm. between centers. The septa number from 32 to 36, the usual number being 36. They are lamellate, thick in the region of the wall and much thinner toward the center, straight and laterally spinose. They are not arranged in the regular cyclical order but regularly alternate in length, the larger septa extending to the columella, the remainder extending less than halfway, and fused or joined by synapticulae to the larger septa. Between the corallites the septa are continued as septo-costae which may be confluent with those of the adjoining corallites or meet them at an angle. The septo-costae have the same thickness as the outer ends of the septa and are equal in size. Although none of the specimens show the upper edges of the septa or septo-costae, the features of the margins may be inferred from the trabecular structure as shown in a longitudinal section of the corallites and represented diagrammatically on Plate 30, figure 9. They are seen to be beaded or notched on their upper margins with the denticulations becoming more pronounced toward the inner edges near the columella. In the calices these inner teeth may simulate pali. From the diagram it also appears that the calices are rather deep with the columella occupying the small space at the bottom. The columella is not represented in the figure. The synapticulae are most abundant in two areas: near the columella and inner edges of the septa, and in the vicinity of the corallite wall. In the latter area they are thin and form a single ring within the corallite and between the septa, distant about 0.3 mm. The synapticulae composing the wall are much thicker than the rest and coalesce to form a more or less solid wall. The dissepiments are thin and well-developed but can be seen only in longitudinal sections. The columella is small and trabecular but appears larger in sections due to its being fused to the inner edges of the septa.

Remarks. At present species of the genus *Diploastrea*[36] are known definitely only from the Oligocene[37] of the West Indies and from the living coral reefs of the Indo-Pacific. The present species possesses all the characters of the family *Oulastreidae* and is referred to *Diploastrea* on the basis of its prominent septal teeth (as deduced from the trabecular structure) and lack of pali. *Cyathomorpha* is distinguished by the presence of wide pali and less perforate septa. *D. harrisi* may have perforate septa, but all of the specimens collected show solid septa due either to secondary filling during life or to fossilization.

D. heliopora (Lamarck) Matthai and *D. crassolamellosa* (Duncan) Vaughan both possess much larger corallites with more septa than the Glen Rose species; in other respects, however, the three species are very similar.

[36] Matthai, G., *Linn. Soc. London Trans.*, ser. 2, Zool., vol. 17, p. 72, 1914. Vaughan, T. W., *Carnegie Inst. Washington*, Pub. 213, p. 142, 1917.

[37] Vaughan, T. W., *U. S. Nat. Mus.*, Bull 103, p. 470 ff., 1919.

Occurrence. Lower Glen Rose, in reef at the Narrows of Blanco River, Blanco County and in Hays County.

Family ANABACIIDAE Duncan

Genus SIDEROFUNGIA Reis, 1889

SIDEROFUNGIA IRREGULARIS Felix

Plate 35, figure 3; Plate 39, figure 2

Siderofungia irregularis FELIX, *1891*, Palaeontographica, 37, p. 151, pl. 22, figs. 12, 12a; *1914*, Fossilium Catalogus I, pars 5, p. 45.

Description. The corallum is in the form of a massive, tall, club-shaped or subplane colony, in which the columnar masses may reach a diameter of 80 mm. and a height of 300 mm. The corallum is bounded by a costate, non-epithecate, common wall. The calices are shallow, close-set, completely circumscribed and polygonal in outline with an average diameter of 5 mm. The edges of the calices are always rounded or obtuse, never sharply angular. There is no wall between the corallites so that the septa of each calice are confluent with those of the adjoining ones over the low, united calicular margins. The septa are thick, straight, perforate, finely dentate on their upper edges, and vary in number from 20 in the younger calices to 50 in the fully grown ones. Beginning with the third, each succeeding cycle of septa is fused to the preceding one so that only the principal septa extend to the center and join the columella. The synapticulae are well-developed and unite the septa. The columella is rudimentary and spongiose. Increase is by intercalicular gemmation, new corallites being partitioned off within the calices of the parent corallites.

Remarks. The specimens of this species from the lower Glen Rose are identical with Felix' description and figures. Two forms may be distinguished which differ by their mode of growth. The one which is commoner in the Glen Rose forms club-shaped or columnar masses, and the other, which is nearer to the Mexican form but rarer in the Glen Rose, forms thin, spreading, subplane, or almost foliaceous masses.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County; and in the basal Glen Rose on Guadalupe River, below Demijohn Bend, Comal County.

Genus POLYPHYLLASTREA d'Orbigny, 1849 (pars)

(*Polyphylloseris* de Fromentel, 1857)

POLYPHYLLASTREA SIMONDSI Wells, n. sp.

Plate 36, figures 4, 5; Plate 39, figure 6

Description. The corallum is in the form of an expanding, pedunculated, more or less foliaceous colony bounded by a finely costulated common wall. The calices form projections or *bourrelets* on the upper surface which are irregularly spaced about 7 mm. apart and attain a height of 3 mm. They range in diameter from 3 to 5 mm. and are marked by a deep central fossette. The septa are thin, perforate, equal, formed of rows of swollen ascending trabeculae, as in *Microsolena* and *Meandraraea*. Their upper edges are beaded and extend over the edges of the calices. They are continuous with the septo-costae which are continuous between the

corallites. They vary in number from 40 to 50, of which only 12 or 15 extend to the center and unite with the rudimentary, spongy columella. The synapticulae are well-developed and unite the septa and septo-costae. Increase is by intracalicular gemmation.

Remarks. This species differs from *P. convexa* d'Orbigny,[38] type of the genus, a common form in the Neocomian of France and Switzerland, by its slightly smaller calices and fewer septa.

The genus *Mastophyllia* was proposed by Felix[39] for a form from the Mexican Neocomian differing from *Polyphyllastrea* only by the presence in the former of a well-developed columella, but it is doubtful if this single feature warrants generic separation and his species *M. conophora* is probably a *Polyphyllastrea*. It differs from *P. simondsi* in its larger number of septa and better-developed columella.

Occurrence. This species has been found only in the reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Genus MEANDRARAEA Étallon, 1859

MEANDRARAEA PLUMMERI Wells, n. sp.

Plate 35, figure 1; Plate 39, figures 7, 8

Description. The corallum forms superimposed, foliaceous, convex or subplane colonies measuring 20–30 mm. in thickness and 100–150 mm. in diameter. The confluent calices are distributed over the upper surface in irregularly concentric series from 15 to 50 mm. in length, with here and there a single calice. The calices and calicular series are shallow and separated by obtuse collines which measure 8 mm. from crest to crest. The calicular series, when viewed in cross section, show the calice centers to be ill-defined and spaced from 2 to 4 mm. apart. The septa are thin, straight, trabeculate and perforate, united by synapticulae, and confluent with those of the adjoining calices without the intervention of a calicular wall. From 40 to 50 septa are grouped about each calicular center, but less than 12 reach the center and join the spongy, rudimentary columella. Along the crests of the collines, where the septo-costae are parallel, from 15 to 17 of the latter may be counted within a space of 5 mm. The thin, costulate epitheca is usually not preserved.

Remarks. This species occurs commonly in the reef near Pleasant Valley Crossing. It is distinguished from *M. steini* (Felix),[40] of the Mexican Neocomian, by its fewer but larger calices, and from *M. sauteri* (Felix)[41] by its parallel arrangement of the collines.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

[38] de Fromentel, E., *Bull. de la Soc. des Sci. de l'Yonne*, vol. 11, p. 275, pl. 10, figs. 11–13, 1857.

[39] Felix, J., *Palaeontographica*, 37, p. 146, 1891.

[40] Felix, J., *Palaeontographica*, 37, p. 147, pl. 23, figs. 1, 1b, 1891.

[41] Felix, J., *Op. cit.*, p. 148, pl. 23, fig. 2, 1891.

MEANDRARAEA SP. CF. M. TULAE (Felix)

Plate 37, figure 3

Latimaeandra tulae FELIX, *1891*, Palaeontographica 37, p. 149, pl. 24, figs. 3, 3a.
Latimaeandraraea tulae FELIX, *1914*, Fossilium Catalogus I, pars 5, p. 60.

Description. The specimens from the lower Glen Rose which have been referred to Felix' species are in the form of small, massive, irregularly convex or knob-like colonies. The calices may be completely circumscribed or several may be united to form short, irregularly confluent series. The ridges or collines separating the calices are relatively high and subangular, and over them the septa are directly confluent. The single calices have a diameter of about 4 mm., and the calicular series may be as long as 15 mm. The septa in one calicular center vary from 30 to 48 in number. They are trabeculate and perforate in structure, as in *Microsolena*, granulate on their upper edges, and may be straight and parallel on the collines of the calicular series, or somewhat geniculate in the single calices. There is no columella.

Remarks. This Glen Rose species is possibly identical with the Neocomian form from Mexico cited above, but the poor condition of the specimens makes the reference uncertain. The species probably groups with *M. globosa* (Prever),[42] from the Cenomanian of Monti d'Ocre (Italy), a form with a globose corallum and slightly smaller calices.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

[42] Prever, P. L., *Mem. Descr. Carta Geol. d'Italia*, vol. 5, pt. 1, p. 101, pl. 8, figs. 8, 9, 10, 10a, 1909.

Genus MICROSOLENA Lamouroux, 1811

MICROSOLENA TEXANA Wells, n. sp.

Plate 37, figure 5; Plate 35, figure 2

Description. The corallum is composed of superposed laminae, becoming massive with age, convex or subplane on the upper surface and bounded by a thin, costulate, epithecate common wall. The calices are superficial and are scattered irregularly over the upper surface, the average distance between centers being 7.5 mm. The septa vary in number from 40 to 50, and are thin, equal, uniting, perforate, beaded on the upper edges, trabeculate in structure, and united by numerous synapticulae. From 11 to 13 of the principal septa extend to the columella. Since there is no corallite wall the septa pass directly to the septo-costae which are extensive and confluent between corallites, straight, curved or geniculate, united by synapticulae, six of them occupying a space of 5 mm. The columella is rudimentary, being formed by a few trabeculate processes. The epitheca is very thin, marked by faint concentric growth lines, usually not preserved. Increase is by lateral gemmation.

Remarks. This species is close to *M. guttata* Koby,[43] a species occurring in the Swiss Urgonian, but which differs from the present one by its considerably larger corallites.

Occurrence. This species is fairly common in the lower Glen Rose.

[43] Koby, F., *Mém. de la Soc. Pal. Suisse*, vol. 24, p. 83, pl. 21, figs. 1, 1a, 2, 2a, 2b, 1897.

Three of the principal localities are: in the reef on Blanco River, one mile above Pleasant Valley Crossing, Hays County; in the reef at the Narrows of Blanco River, Blanco County; and in the limestones of the *Arctica roemeri* beds about 200 feet above the base of the Glen Rose on the Crane's Mill-Hancock road, Comal County.

Genus DIMORPHARAEA de Fromentel, 1861

DIMORPHARAEA *sp.* cf. D. BARCENAI (Felix)
Plate 37, figure 4

Thamnastraea barcenai FELIX, *1891*, Palaeontographica 37, p. 144, pl. 23, fig. 7, pl. 22, fig. 3; *1914*, Fossilium Catalogus I, pars 5, p. 50.
Dimorpharaea barcenai GREGORY, *1900*, Palaeontologia Indica, ser. 9, vol. 2, pt. 2, p. 189.

Description. The single badly worn specimen from the lower Glen Rose does not show the form of the colony or the calicular surface, and the reference to Felix' species is based on sections. The corallite centers are from 5 to 10 mm. apart and are not separated by a wall. The septa number from 30 to 40 and are directly confluent with those of neighboring calices through septo-costae. They are alternately thick and thin, united by well-developed synapticulae, trabecular in structure, straight or curved, with the principal ones extending to the senter where they join a spongy columella. About 15 septo-costae occupy a space of 5 mm.

Remarks. This form is apparently identical with *D. barcenai* as regards details of internal structure, but since so little is known of the exterior the identification can only be temporary.

Occurrence. In the coral reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

Suborder MADREPORARIA PERFORATA Edwards and Haime

Family HETEROCOENIIDAE Oppenheim, 1930

Genus HETEROCOENIA Edwards and Haime, 1849

HETEROCOENIA(?) HILLI Wells, n. sp.
Plate 31, figure 8; Plate 32, figure 4

Description. The corallum is in the form of a branching colony, dividing irregularly with more or less cylindrical branches about 5 mm. in diameter. The calices are placed on the extremities of the branches and have a diameter of 2 mm. The corallites are surrounded by a thick coenenchyme, the surface of which is tuberculate. The septa are granulate on their sides, 12 in number, arranged in two cycles and only three systems. Three of the primary septa extend more than halfway to the center of the corallite, the remaining three are but half as long, and the secondary septa are rudimentary. There is no columella.

Remarks The determination of this species is difficult because only casts of the interiors of the corallites and impressions of the surface of the corallum are preserved. Its form is like that of *H. costata* Felix[44] from the Senonian of Gosau (Austria), and in the manner of preservation it is like *Gorgonia bacillaris* Goldfuss[45] of the Maestrichtian.

[44] Felix, J., *Palaeontographica* 49, p. 237, pl. 19, figs. 4, 5, 8, 9, 1903.
[45] Goldfuss, A., *Petrefacta Germaniae*, p. 18, pl. 7, figs. 1–16, 1826–33.

Occurrence. In the limestones of the *Arctica roemeri* beds 200 feet above the base of the Glen Rose, on the Crane's Mill-Hancock road, Comal County.

Family ACROPORIDAE Verrill

Genus ASTREOPORA de Blainville, 1830

ASTREOPORA(?) LEIGHTONI Wells, n. sp.

Plate 36, figure 6

Description. The corallum forms a branching colony with irregularly distributed calices which do not project above the surface of the coenenchyme. The calices are from 0.5 to 0.7 mm. in diameter; their edges are rounded and not sharply defined. The usual number of septa is six, although in some calices only five may be found. They are not well-developed and appear as ridges on the interior of the corallite extending less than a third of the distance to the center. The surface of the coenenchyme is echinulate and often raised in ridges extending between the calices, simulating costae. There is no evidence of a columella. Internal characters of the coenenchyme and corallites unknown.

Remarks. This species is based upon a single specimen in the form of a mold of the exterior surface. The distinguishing features are the small calices and the echinulate, pseudocostate surface of the coenenchyme. It is referred very doubtfully to *Astreopora* mainly because it seems to be a perforate coral with rudimentary septa lacking a columella. Externally it differs from *A. hexaphylla* Felix,[46] from the Senonian of Galicia, in the smaller number of septa (12 in Felix' species) and slightly smaller calices.

Occurrence. In the lower Glen Rose in Comal County; exact locality unknown. Probably from the *Arctica roemeri* Beds.

Genus EPIPHAXUM Lonsdale, 1850

EPIPHAXUM LABYRINTHICUM Wells, n. sp.

Plate 37, figure 8

Description. The colony is thin and encrusting, occasionally sending up a short, branch-like projection or proliferation bearing several corallites. The Glen Rose specimens are usually found encrusting the shells of an *Alectryonia* and are less than 1 mm. in thickness. The surface of the coenenchyme is marked by a labyrinthine arrangement of the granulations reflecting the internal character of the coenenchyme. The calices are slightly elevated above the surface and are spaced at distances varying from 0.3 to 2.0 mm. Their diameter averages 0.6 mm. with a maximum of .75 mm. the septa are poorly developed and appear as 24 low ridges within the calices merging with the coenenchyme at the surface. Outside the false corallite wall the costal extensions of the septa meet the coenenchyme, forming a girdle of rounded pores as in *E. vermiculatum* (pl. 37, fig. 7).

Remarks. This species is close to the Senonian *E. vermiculatum* Felix[47]

[46] Felix, J., *Zeitschr. deutsch. geol. Ges.* 58, p. 45, pl. 3, figs. 7, 7a, 1906.

[47] Felix, J., *Palaeontographica* 49, p. 358, pl. 22, fig. 9, text fig. 67, 1903.

but possesses smaller and more uniform calices.

Occurrence. In the reef in the lower Glen Rose on Blanco River, one mile above Pleasant Valley Crossing, Hays County.

(?) Family CHAETETIDAE Edwards and Haime

COMALIA Wells, n. gen.

Description. The corallum is colonial, massive, forming more or less columnar masses covered laterally by a wrinkled epitheca. The corallites are slender, tall, prismatic, polygonal in outline, or subtriangular, with deep calices opening vertically. The imperforate corallite walls are separate, sometimes united by thin exotheca, occasionally fused near the calices. The septa are rudimentary but relatively well-developed for this group of corals, forming three ridges on the corallite wall, as in the Paleozoic genus *Alveolites*. One of the septa is usually better developed than the others and extends from the wall nearly to the center of the corallite where it terminates in a swelling or bifurcation. Tabulae are well-developed, numerous, confined to the individual corallites, i.e., not extending between the corallites, arching upwards slightly. Increase is by gemmation.

Remarks. Specimens of the species of this form as described below are usually in a very poor state of preservation, being filled internally with granular calcite, but the characters are shown by a few fragments.

The nearest affinities appear to be with *Chaetetes* Fischer de Waldheim (doubtfully ranging into the Cretaceous), *Diplochaetetes* Weissermel,[48] and *Blastochaetetes* Dietrich[49] but *Comalia* is distinguished from all three by the presence of the three relatively well-developed septa. More particularly, it differs from *Chaetetes* and *Blastochaetetes* by the separation of the corallite walls, and from *Diplochaetetes* by the mode of increase, more abundant tabulae and better developed septa.

The type species is *Comalia fasciculata*, Wells, n. sp., from the lower Glen Rose formation.

COMALIA FASCICULATA, Wells, n. sp.

Plate 30, figures 11, 11a; Plate 37, figure 2

Description. Characters of the genus described above.

The corallites are grouped in fasciculate bundles from 15 to 20 mm. in diameter rising to a height of more than 25 mm. from the common base which may be as much as 250 mm. in extent. They are subtriangular or semicircular in outline, with deep calices. The longer diameter of the calices averages 1.4 mm., the shorter 1.0 mm., and the depth may be as much as 5.0 mm. Three rudimentary septa are present within the corallites, forming ridges on the walls. The principal septum extends nearly to the center for a distance of .5 mm.,

[48] Weissermel, W., Neues ueber Tabulaten, Hydrozoën, und eine Hexacoralle aus dem Tertiär der Bogenfelser Diamantfelder. *In* Kaiser, *Diamantgebeit*, bd. ii, p. 88 et seq., pl. 35, figs. 1, 2; text taf. C, figs. 1–3, 1926.

[49] Dietrich, W. O., Ueber sogenannte Tabulaten des Jura u. d. Kreide, besonders die Gattung *Acantharia* Qu. *Centralbl. f. Min.* usw., p. 208, 1919.

terminating in a swelling or bifurcation. The tabulae are horizontal, arched upward in the middle, 15 of them occupying a space of 10 mm. The exterior of the corallum is covered by a wrinkled epitheca marked by lines of growth.

Occurrence. Several large masses of this species, very poorly preserved, occur in the coral reef in the lower Glen Rose on Blanco River one mile above Pleasant Valley Crossing, Hays County.

Subclass ALCYONARIA Edwards

Family HELIOPORIDAE Moseley

Genus POLYTREMACIS d'Orbigny, 1849
(*Heliopora* de Blainville?)

POLYTREMACIS(?) HANCOCKENSIS Wells, n. sp.
Plate 35, figure 5

Description. The colony is massive or encrusting. The autopores have a diameter of 1.0 mm. and are imbedded in a coenenchyme composed of small siphonopores forming interspaces of 0.5–0.8 mm. The septa are rudimentary, 18 in number, forming vertical ridges on the walls of the autopores.

Remarks. The single specimen of this species is preserved as a mold of the upper surface, so that any details of the internal structure are lacking. *P. urgonensis* Koby[50] from the Swiss Urgonian, has the same general aspect but has only from 10 to 12 septa. The generic reference cannot be at all certain until more complete specimens are found.

Occurrence. In the limestones of the *Arctica roemeri* beds 200 feet above the base of the Glen Rose on the Crane's Mills-Hancock road, Comal County.

[50] Koby, F., *Mém. de la Soc. Pal. de la Suisse*, vol. 24, p. 87, pl. 21, fig. 5, 1897.

TYPE SPECIMENS of all new species described in this paper are in the collections of the Department of Geology, University of Texas, with exception of the type of *Epiphaxum labyrinthicum*, which has been deposited in the United States National Museum.

NOTE. Referring to *Hydnophora (?) blancoensis*, described on p. 243, attention is called to Oppenheim's recent "*Anthozoen der Gosanschichten*" which shows that *H. styriaca* Reuss is a fungid coral. Oppenheim has made Reuss' species the type of a new genus, *Hydnophorarea*.

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DECORAH SHALE CONODONTS FROM KANSAS[1]

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ABSTRACT

Some of the deep wells in central Kansas penetrate Ordovician shales carrying the Decorah fauna. Among the common fossil forms are conodonts like those occurring in this shale in Minnesota and Iowa. A well in Reno County yielded nearly a score of species that have not been found as yet in the more northern area and hence appear to be new. These latter are here described.

Ordovician formations are encountered in drilling at various places in the southern Great Plains. A detailed study of these sediments in and adjacent to the Mid-Continent oil fields is now being made by Fanny C. Edson. It is on some of her materials that the present paper is based and the author is indebted to Mrs. Edson for the privilege of studying and describing these species.

The deep wells of Kansas and Oklahoma often penetrate shales and dolomitic limestones that contain a Black River fauna. In the cuttings many of the typical Decorah fossils have been found and the formation which carries this fauna is commonly designated by that name. The Decorah shale of the Kansas and Oklahoma region consists of bright green to olive-green shales with occasionally some maroon beds. Interstratified with the shale may be light gray dolomitic limestones and, less frequently, beds of sandstone. The shale is argillaceous but always contains scattered subangular frosted grains of sand. In some parts of Kansas the Ion, the Guttenberg, and the Spechts Ferry members, as defined by Marshall Kay,[2] are present, but it is only the latter in Kansas that is commonly called the Decorah shale. The upper divisions are probably included with the Galena limestone which is present at some places in these states of the central southwest. The shale rests unconformably on Canadian dolomites and its upper surface, together with middle Ordovician formations, has several times suffered from erosion. As a result the Decorah shale remnant varies from zero to several hundred feet in thickness.

The well (Gypsy Oil Company, Hudson No. 1) which furnished the conodonts here described, is located in the "center south line NE¼ Section 27, T. 24 S., R. 10 W., Reno

[1] This contribution is made possible through the research funds of the Graduate School, University of Minnesota.

[2] *Jour. Geology*, vol. 37, pp. 639–671, 1921.

County, Kansas." In this well the Decorah shale was encountered at 4,154 feet below the surface and extended down to 4,300 feet where the drill passed into a "dolomite of Canadian age." Conodonts in the Decorah shale of Kansas are not limited to this one occurrence but have been found in the Ordovician cuttings of numerous other wells in the state. They serve as one of the means of recognizing this formation.

Conodonts, it may be said, are small crests of teeth or plate-like bodies, almost microscopic in size, which have been regarded as belonging to the Annelida, to the Mollusca, to various of the Crustacea but are now thought to be the teeth and dermal plates of primitive fishes. It is possible, however, that they may have belonged to some entirely extinct class of animals somewhat lower in the life scale than fishes. The teeth are amber-colored, highly polished little bodies which evidently have been attached to cartilaginous tissue or skeletal material of some sort, fragments of which occasionally are still sticking to them. The tooth or crest of teeth usually consists of a bar from which tooth-like projections appear to rise as structurally continuous parts of the bar. Many of them, however, have denticles that are lighter in color than the bar and may be white or colorless. Among these it is often possible to see that the denticle, in some genera at least, penetrates the bar and is thus set into it somewhat like the tooth in the jaw of an ordinary vertebrate. A genus that shows this especially well is *Hindeodella*. Some of the crests have hollow bases or bars and the hollow may extend into the cusp or even into the larger denticles. Occasionally some structure may be observed in the tooth itself, but generally the recrystallization of the material of the tooth renders that observation uncertain. Those interpreted as dermal plates seem to be single pieces with basal portions adapted to imbedding in the tissue. The conodonts from the Decorah shale, or its equivalent, in Kansas are well preserved and are similar to or identical with those found in that formation in Minnesota.

In addition to the fragments of the common larger Black River fossils, samples from this one well (Hudson No. 1) have furnished specimens of the following:

Conodont fauna from the Gypsy Oil Company's Hudson No. 1 well, Reno County, Kansas

Distacodus arcuatus Stauffer.
Drepanodus curvatus Stauffer, n. sp.
Euprioniodina crassa Stauffer, n. sp.
Euprioniodina robusta Stauffer
Hibbardella (?) *gracilis* Stauffer
Hibbardella peculiaris Stauffer, n. sp.
Hindeodella serrata Stauffer, n. sp.
Lonchodus aequidentatus Stauffer
Lonchodus arcuatus Stauffer, n. sp.
Lonchodus brevidentatus Stauffer, n. sp.
Lonchodus crassidentatus Stauffer, n. sp.
Lonchodus dentatus Stauffer
Lonchodus pectinellus Stauffer, n. sp.
Lonchodus spinuliferus Stauffer, n. sp.
Lonchodus striatus Stauffer, n. sp.
Panderella falciformis Stauffer, n. sp.
Polygnathus sp. undet.
Prioniodina macrodenta Stauffer, n. sp.
Prioniodus aculeatus Stauffer
Prioniodus apicalis Stauffer, n. sp.
Prioniodus calcaratus Stauffer

Prioniodus (?) *crebratus* Stauffer, n. sp.
Prioniodus cristulus Stauffer
Prioniodus cultellatus Stauffer
Prioniodus (?) *dentatus* Stauffer, n. sp.
Prioniodus kansasensis Stauffer, n. sp.
Prioniodus (?) *obliquus* Stauffer
Prioniodus siculatus Stauffer, n. sp.
Prioniodus speciosus Stauffer, n. sp.
Prioniodus sp. undet.
Subprioniodus hamatus Stauffer, n. sp.
Subprioniodus incurvatus Stauffer, n. sp.
Subprioniodus remotidentatus Stauffer, n. sp.

The new species in this list, and here described, are all from samples of the shales between the 4,154- and 4,300-foot levels in the Hudson well No. 1, Reno County, Kansas. Other fragments of conodonts are common but specimens sufficiently complete for description have not been found.

Family DISTACODIDAE Ulrich and Bassler, 1926

Genus DREPANODUS Pander, 1856

DREPANODUS CURVATUS Stauffer, n. sp.

Plate 40, figure 1

Tooth consisting of a single long curved cusp. It is slightly broken at the base but apparently without a definite bar.

Family PRIONIODIDAE Ulrich and Bassler, 1926

Genus PRIONIODUS Pander, 1856

The great variety of forms that have been included in this genus makes it difficult to know which individual species should be assigned to it. However, it is probable that a number of those referred to *Prioniodus* should be separated and erected into a new genus or subgenus.

PRIONIODUS ACULEATUS Stauffer

Plate 40, figure 2

Prioniodus aculeatus STAUFFER, *1930*, Jour. Pal., vol. 4, p. 126, pl. 10, fig. 12.

The specimens here illustrated are found among the cuttings from this well and evidently belong to *P. aculeatus*, but they suggest some additional characteristics not included in the original description. Posterior to the cusp there may be either two or three small sharp denticles succeeded by a series of slightly increasing larger denticles. The number of individuals in this latter is five or six and perhaps more.

PRIONIODUS APICALIS Stauffer, n. sp.

Plate 40, figure 3

Short rounded bar with a sharp nearly straight cusp rising from the end and forming an approximate right angle with the bar. Below the bar, however, the cusp curves rapidly backward and terminates abruptly. The upper margin of the bar bears five slender denticles, the first three of which increase in length from the cusp and are nearly parallel to it. The last two incline away from the others and make an acute angle with the bar.

PRIONIODUS CALCARATUS Stauffer

Plate 40, figure 4

Prioniodus calcaratus STAUFFER, *1930*, Jour. Pal., vol. 4, p. 126, pl. 10, fig. 13.

This specimen shows more denticles than were present on the type. Undoubtedly there are more of these minor denticulations in the complete specimen of many of the species illustrated. It is exceedingly difficult to find such complete specimens.

PRIONIODUS (?) CREBRATUS Stauffer, n. sp.
Plate 40, figure 5

Bar straight with five denticles partly preserved and the impressions of three or four others shown. Denticles with two sharp edges, straight, rather slender, pointed, closely spaced and extending at right angles to the bar. The bar thickens and increases in width, towards the left in the illustration, where a large cusp is probably broken off.

PRIONIODUS CRISTULUS Stauffer
Plate 40, figure 6

Prioniodus cristulus STAUFFER, *1930*, Jour. Pal., vol. 4, p. 128, pl. 10, fig. 19.

The bar is straight, thick, massive and has a number of denticles arising from its upper surface. Above the bar the cusp is nearly straight and extends upward at almost a right angle. Below the bar, however, extension of the cusp curves rapidly toward parallelism with the bar.

PRIONIODUS CULTELLATUS Stauffer
Plate 40, figures 8, 9

Prioniodus cultellatus STAUFFER, *1930*, Jour. Pal. vol. 4, p. 126, pl. 10, fig. 11.

These fragmentary specimens show a very characteristic cusp and one specimen preserves a few of the denticles. There are other similar specimens in the collection and perhaps the species was common.

PRIONIODUS (?) DENTATUS Stauffer, n. sp.
Plate 40, figure 10

Base short, thick, curved and bearing a series of denticles increasing in

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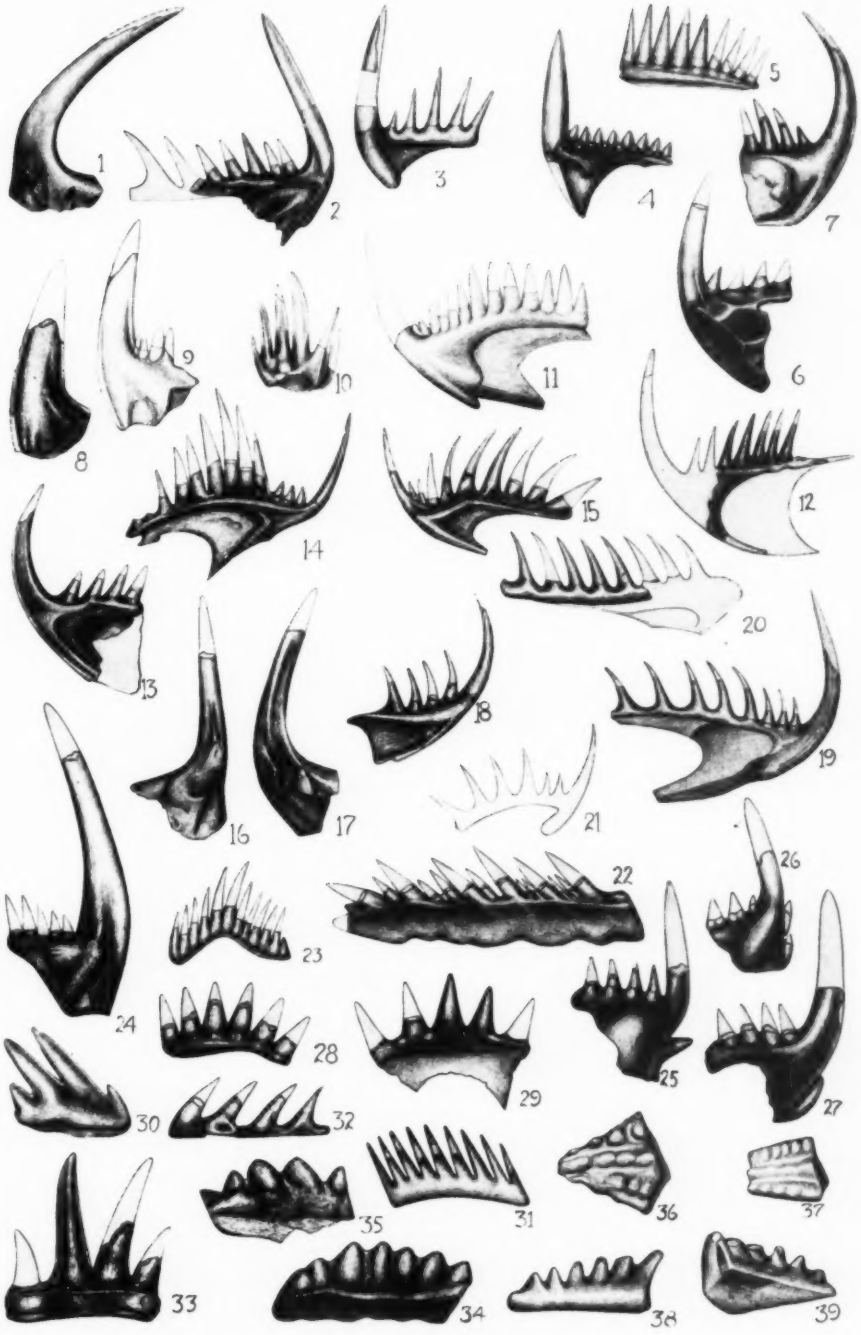
EXPLANATION OF PLATE 40

Drawings by Faith Patterson. Magnification about 30 diameters.

FIGS. 1—*Drepanodus curvatus* Stauffer n. sp.
2—*Prioniodus aculeatus* Stauffer n. sp.
3—*Prioniodus apicalis* Stauffer n. sp.
4—*Prioniodus calcaratus* Stauffer.
5—*Prioniodus* (?) *crebratus* Stauffer n. sp.
6—*Prioniodus cristulus* Stauffer n. sp.
8, 9—*Prioniodus cultellatus* Stauffer.
10—*Prioniodus* (?) *dentatus* Stauffer n. sp.
11—*Prioniodus kansasensis* Stauffer n. sp.
7, 12, 13—*Prioniodus siculatus* Stauffer n. sp.
14, 15—*Prioniodus speciosus* Stauffer n. sp.
16, 17—*Prioniodus* sp.
18—*Subprioniodus hamatus* Stauffer n. sp.
19, 20—*Subprioniodus incurvatus* Stauffer n. sp.
21—*Subprioniodus remotidentatus* Stauffer n. sp.
22—*Hindeodella serrata* Stauffer n. sp.
23—*Prioniodina macrodenta* Stauffer n. sp.
24—*Euprioniodina crassa* Stauffer n. sp.
25—*Euprioniodina robusta* Stauffer.
26, 27—*Hibbardella peculiaris* Stauffer n. sp.
28—*Lonchodus arcuatus* Stauffer n. sp.
29—*Lonchodus brevidentatus* Stauffer n. sp.
30—*Lonchodus crassidentatus* Stauffer n. sp.
31—*Lonchodus pectinellus* Stauffer n. sp.
32—*Lonchodus spinuliferus* Stauffer n. sp.
33—*Lonchodus striatus* Stauffer n. sp.
34, 35—*Panderella falciformis* Stauffer n. sp.
36, 37—*Polygnathus* sp.
38, 39—*Polygnathus* sp.



Stauffer, Ordovician Conodonts

size. The specimen as illustrated is fragmentary. To the right there may be one or two more denticles than shown. A true cusp is lacking or has been broken off.

PRIONIODUS KANSASENSIS Stauffer, n. sp.
Plate 40, figure 11

Bar slender, long, and slightly curved, the upper surface set with a series of a dozen or more stout pointed denticles which are crowded and slightly fused at their bases. The bar extends into the cusp at the anterior end. That portion of the cusp below the bar is thick and forms an acute angle (about 40 degrees) with the bar. Above, the angle is obtuse and about 120 degrees. This specimen is still attached to a portion of the original tissue.

PRIONIODUS SICULATUS Stauffer, n. sp.
Plate 40, figures 7, 12, 13

Bar slender with a strong hooked or curved cusp rising from the end. The cusp extends below the bar and is continued as such nearly half the length of the cusp above the bar. The long slender denticles make an angle of about 75 degrees with the bar. The inner side of the cusp (fig. 13) shows a groove near the outer margin and the curve is in the same plane as the cutting edge of the cusp.

PRIONIODUS SPECIOSUS Stauffer, n. sp.
Plate 40, figures 14, 15

Bar long, arched towards the anterior and terminating in a slender cusp. This latter extends slightly below the bar. Between the lower extension of the cusp and the bar some of the tissue is still preserved. Denticles arranged in a tortuous or flexed row beginning with three small ones near the cusp. Following these there are two of increased length, then three as long as and more sturdy than the cusp, followed by three or four in descending series.

Figure 15, which is regarded as a variation of this species, shows less sinuosity of the denticulated edge, denticles less crowded, and the three near the cusp longer and more slender.

PRIONIODUS sp.
Plate 40, figures 16, 17

These two specimens are somewhat fragmentary and may not represent the same species. They each consist of a stout base with a strong sharp edged cusp rising from the elevated part. Several denticles are shown but they are fragmentary.

Genus SUBPRIONIODUS Smith, 1907

SUBPRIONIODUS HAMATUS Stauffer, n. sp.
Plate 40, figure 18

Bar slender, short, grading into a curved terminal cusp which is produced below the bar. Four sharp curving denticles are present but the bar is somewhat broken and probably carried at least one or two more. An impression of tissues, perhaps chitinous or bony, shows below the bar.

SUBPRIONIODUS INCURVATUS Stauffer, n. sp.
Plate 40, figures 19, 20

Nearly straight slender bar terminating in a curved cusp that ex-

tends slightly below the bar. The cusp is marked by a slight keel or ridge along the side. The upper edge of the bar is set with a series of slender, sharp, curving denticles that are more distantly spaced with increasing distance from the cusp. The attached tissues seem to be chitinous rather than bony.

SUBPRIONIODUS REMOTIDENTATUS Stauffer, n. sp.

Plate 40, figure 21

Bar slender, terminating in a slender cusp. This is followed, along the upper margin of the bar, by two short denticles and then four or possibly more longer distantly spaced denticles. An impression only is preserved.

Family PRIONIODINIDAE Ulrich and Bassler, 1926

Genus HINDEODELLA Ulrich and Bassler, 1926

HINDEODELLA SERRATA Stauffer, n. sp.

Plate 40, figure 22

Bar long and thick, triangular in cross-section. Denticles alternating, one long and two short. All of the denticles may be seen in the translucent amber-colored bar, but in some cases the short or smaller ones do not appear above it. The denticles are inclined to the bar at an angle of about 45 degrees. This angle decreases towards the tapering end of the bar where the larger denticles are more crowded together and the smaller alternating ones are reduced in number. During life possibly the crest was normally increased by growth in that direction. The cusp was to the right.

Genus PRIONIODINA Ulrich and Bassler, 1926

PRIONIODINA MACRODENTA Stauffer, n. sp.

Plate 40, figure 23

Bar arched, slightly flexed, grading upward into the denticles of which there are five to seven showing on either side of the central larger one. This latter rises from the crest of the arch and may be called a cusp.

Genus EUPRIONIODINA Ulrich and Bassler, 1926

EUPRIONIODINA CRASSA Stauffer, n. sp.

Plate 40, figure 24

From the short thick bar or base rises a stout curved cusp with sharp edges. Along the bar, on one side of the cusp, are preserved four or five short denticles. This is apparently a left tooth. Another with it, not drawn, is an opposite. Curve or twist of the cusp not in the plane of the cutting edge.

EUPRIONIODINA ROBUSTA Stauffer

Plate 40, figure 25

Euprioniodina robusta STAUFFER, *1930*, Jour. Pal., vol. 4, p. 123, pl. 10, fig. 1.

The following redescription adds a little to that formerly given. Bar arched to angular. Flattened cusp rising from apex of bar and turned back almost in line with the prolongation of one leg of the bar. This latter has one stout denticle and perhaps the base of another showing wide spacing of denticles. The other leg or limb of the bar shows four

rather closely set denticles extending nearly parallel to the cusp itself. The space within the arch of the bar is filled by bone-like material. This latter is brown in color and somewhat in contrast to the clear amber color of the bar, cusp and denticles.

Genus HIBBARDELLA Ulrich and Bassler, 1926

HIBBARDELLA(?) PECULIARIS Stauffer, n. sp.
Plate 40, figures 26, 27

Bar or plate fragmentary but doubtless more or less triangular and gradually merging at the upper apex into a stout cusp. This latter curves out of the plane of the basal plate. One leg of the triangular bar shows three or four denticles which diverge at a small angle from the cusp. The other leg shows one or two denticles which tend to follow the direction of the cusp. One specimen is apparently waterworn.

Genus LONCHODUS Pander, 1856

LONCHODUS ARCUATUS Stauffer, n. sp.
Plate 40, figure 28

Six subequal denticles rise from a thick arcuate bar. The base of the bar is flattened and bears a groove along its center. The plane of the curve of the bar is at right angles to the direction of the teeth and not well shown by the figure. The bar is broken near the end (to the left in the figure) and probably bore several more denticles when complete. The denticles are white and the bar is the usual amber color. The broken end shows that the denticles are set into, as well as being a part of, the bar.

LONCHODUS BREVIDENTATUS Stauffer, n. sp.
Plate 40, figure 29

Bar thin, straight, except near one end where it dips down slightly. From the upper surface of the bar rise five short, blunt denticles. Beneath the bar indefinite impressions of the tissues are preserved.

LONCHODUS CRASSIDENTATUS Stauffer, n. sp.
Plate 40, figure 30

This is apparently a waterworn specimen, or the wear may have taken place during the drilling process. The end to the right in the illustration is probably broken off. The tooth or crest consists of a stout bar with equally stout denticles, closely spaced and making an angle of about 45 degrees with the bar. Three of these denticles, with a fragment of the fourth, are preserved. The bar is unusually thick in the central portion.

LONCHODUS PECTINELLUS Stauffer, n. sp.
Plate 40, figure 31

Slender, slightly arched bar with a series of subequal denticles closely set along the upper edge and slightly inclined to the bar. Denticles distinct and equidistant.

LONCHODUS SPINULIFERUS Stauffer, n. sp.
Plate 40, figure 32

Bar slender, straight and preserving four slender, flattened, distantly spaced denticles which are slightly curved but make an angle of about 40 degrees with the bar. The left end in the illustration is slightly displaced due to fracture in the rock.

LONCHODUS STRIATUS Stauffer, n. sp.
Plate 40, figure 33

Bar nearly straight, flat on under side except for a slight groove down center. At least four stout diverging denticles on top of bar. The denticles are striated and flattened in the plane of the series, but slightly curved at right angles to it.

Family POLYGNATHIDAE Ulrich and Bassler, 1926

Genus PANDERELLA Ulrich and Bassler, 1926

PANDERELLA FALCIFORMIS Stauffer, n. sp.
Plate 40, figures 34, 35

Base straight, thick, with a row of short rounded or blunt tubercles. Under side of base keeled. The fragments that have been found show five to seven tubercles, but there probably were more. The material composing these specimens is slightly different from that commonly forming the conodonts. It is darker and opaque.

Genus POLYGNATHUS (Hinde) Bryant, 1921

POLYGNATHUS sp. undet.
Plate 40, figures 36, 37

Broken plates with ridges and rows of tubercles occur among the crests of teeth. Some of these resemble certain species of *Polygnathus* and doubtless belong to that genus. Others, however, are more like the "sculptured dermal (?) plates" found by Bryant in the conodont bed of Devonian age along Eighteen Mile Creek west of Buffalo, New York. Such fragmentary plates are often exceedingly abundant among the conodonts of the Decorah shale in Minnesota but they seldom show enough of the outline to determine their shape or probable function. However, they seem to be external plates.

POLYGNATHUS sp. undet.
Plate 40, figures 38, 39

Two views of a plate of somewhat unusual appearance. It seems more likely to have been on the surface than in the mouth of the animal bearing it. The plate is stout, massive and bears a row of tubercles or denticles on the upper surface.

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FORAMINIFERA FROM THE RIPLEY FORMATION OF WESTERN ALABAMA[1]

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ABSTRACT

This contribution on the foraminifera from the Upper Cretaceous sediments of the southeastern part of the Gulf Coastal Plain describes 44 species, 10 of which are regarded as new. Relationships with Upper Cretaceous faunas of the southwestern United States, Mexico, and Europe are indicated.

INTRODUCTION

The foraminiferal faunas of the Upper Cretaceous in the Gulf Coastal Plain lately have received marked attention, and much information has been added to our knowledge of them. Especially have many significant facts been contributed about the faunas of the western and central portions of the Gulf Embayment, where close correlations undoubtedly soon may be anticipated. The notable progress which recently has been made in the publication of data on these western and central exposures, however, has not been attained in the equally interesting and important southeastern extension of this great arc of Cretaceous sediments. It is with the object of furnishing information on the foraminiferal faunas particularly of these southeastern deposits that this paper has been prepared.

[1] Published with the permission of the State Geologist of Alabama.

The desirability of obtaining data on the Cretaceous foraminifera of the southeast became apparent to the writer in 1925, and early in 1927 a series of systematic collections from these beds was privately begun. Later, with the assistance and coöperation of the Alabama Geological Survey, it was possible to extend the collecting so that the area covered included a large part of the Cretaceous belt reaching from Georgia to Mississippi. Altogether over 300 stations were established, from which more than 1000 samples were obtained. The species presented in this paper came from samples collected along Alabama River between Portland and Prairie. Because most of the roads near the river were impassable with an automobile, the collecting was carried on principally by means of boats. The localities from which the accompanying species were obtained are as follows:

FOSSIL LOCALITIES

Barton's Bluff, Locality 53. About eight miles above Moscow on the Tombigbee River there is an exposure of some 60 feet in which both the Selma chalk and the Ripley occur. This is a fault zone where vertical displacement has brought the two facies into juxtaposition. The Ripley at this point is highly calcareous, but presents the usual sandy, glauconitic aspect as well, and is very similar to the exposure at the mouth of Boguechitto Creek. It contains a rich foraminiferal fauna.

Prairie Bluff, Locality 87. This locality on the Alabama River, made classic by the early work of Toumey,[2] Winchell,[3] and Smith,[4] is about six miles southeast of the town of Catherine, Wilcox County, and may be reached by a local road from this village to the old Prairie Post Office. The exposure forms a bluff about 100 feet high with the strata dipping at the unusual rate of 300 feet to the mile. At the top there is a blue limestone containing *Exogyra costata* Say, *Gryphea vesicularis* Lamarck, and large numbers of phosphatized shell casts. It has a thickness of 8 to 10 feet. Below this stratum there occurs a sandy-chalk deposit approximately 20 feet thick. The lower part of this bed, near the middle of the bluff, is marked by a hard ledge made up largely of shells. The remainder of the exposure, extending to water level, consists of beds of loose richly glauconitic, slightly argillaceous sands alternating with indurated ledges of the same materials, apparently cemented by calcareous deposits. Macrofossils occur frequently but are not abundant. The foraminifera found at this locality are uniformly small, and a few species are represented. The fauna occurring in the sandy beds is especially impoverished. This is Upper Ripley.

Rocky Bluff, Locality 88. One mile above Prairie Bluff on Alabama River there is an exposure of Ripley in a low cliff, called Rocky Bluff by Smith. Only the basal part, about 15 feet in thickness, has been examined, since the upper beds are the same as those at Prairie Bluff. These lower strata appear to be a downward continuation of the alternating soft sands and indurated ledges of the lower part of the exposure at Prairie Bluff. They have similar steep dips, and probably in both cases these may be attributed to depositional slopes. Macrofossils are present but not abundant. A restricted foraminiferal fauna has been found.

Pine Barren Creek, Locality 104. Half a mile above the mouth of Pine Barren Creek there is a bluff, about 15 feet high, exposing Ripley strata. At the top there are 5 feet of gray micaceous sand and clay, and below this, 10 feet of black micaceous clay. The gray beds contain foraminifera in abundance, while only a sparse fauna is present in the black sediments.

Red Bluff, Locality 105. Just north of the boundary between Wilcox and Dallas counties on Alabama River there is a remarkably high bluff in the lower part of which 40 to 50 feet of Ripley are exposed. This deposit is massively bedded, and consists of alternating layers of dark-blue micaceous clay, and clay containing varying amounts of fine sand. The clay is predominant. Large fossils are present, but not abundant. A rich microfauna has been found. The horizon appears to be low in the Ripley of this region.

Boguechitto Creek, Locality 106. A low bluff occurs at the point where Boguechitto Creek joins Alabama River, and a fault brings the chalk up against the lower Ripley beds. The displacement appears to be about 25 feet. The Ripley strata are typical calcareous ledges, and contain numerous macrofossils. The microfauna from this horizon is exceedingly rich and well-developed. The upper part of the chalk exposed at this locality contains *Exogyra costata* and *E. ponderosa*. It has a great many foraminifera, but the fauna does not appear to be as rich as that of the immediately overlying Ripley beds.

RELATIONSHIPS OF THE FAUNA

The foraminifera of the Ripley formation in Alabama, in general, bear a close relationship to the Cre-

[2] Toumey, M., First Bien. Rept., *Ala. Geol. Survey*, 1850.

[3] Winchell, A., *Proc., Am. Assn. Adv. Sci.*, vol. 10, p. 90, 1856.

[4] Smith, Eugene A., Geology of the Coastal Plain of Alabama, *Ala. Geol. Survey, Rept.*, 1894; *U. S. Geol. Survey*, Bull. 43, p 189.

taceous faunas of neighboring regions, especially to those of the central and western part of the Gulf Coastal Plain. A number of species common in the Navarro and Taylor formations of Texas have been found, as well as many forms characteristic of the Velasco shale of Mexico. The Saratoga chalk fauna of Arkansas is well represented, and practically all of the species from the Ripley of Tennessee occur in Alabama. A most striking parallelism with the fauna from the Cretaceous marls of the Bavarian Alps[5] is apparent, and there is marked similarity to the European Cretaceous faunas described by d'-Orbigny and Reuss. Several species now living in the shallower waters of the Caribbean and the Gulf of Mexico are present, and the occurrence of these, together with the presence of a large proportion of species common in the Mediterranean Cretaceous, suggests that the Ripley sea was moderately warm, or warm temperate, and shallow. Analytical comparisons of the Ripley species with those of other regions cannot be presented at this time because the accompanying fauna is in no measure complete, including only a small proportion of the forms encountered at the localities represented. The results are qualitative, rather than quantitative, and a thorough analysis of the fauna must await further study and more extensive means of publication.

TYPES

The holotypes and morphotypes of the species described in this paper will remain in the possession of the author. Topotypes will be deposited at Princeton University and in the Alabama Museum of Natural History (Walter B. Jones, Director), University, Alabama.

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The writer acknowledges the kindness of Helen Jeanne (Mrs. F. B.) Plummer in reading the manuscript of this paper, and in offering numerous valuable suggestions which have been incorporated in the work. Field work for this investigation was financed partially by the Alabama Geological Survey. The Geology Department of Princeton University contributed funds for the preparation of the illustrations. Illustrations for this paper were prepared under the writer's direction by Mr. Roy C. Kneeland, School of Industrial Arts, Trenton, N. J.; Miss Emily H. Tupper, of Princeton, and Messrs. C. F. Brauer and W. L. Gordon, students in the Department of Architecture, Princeton University.

DESCRIPTION OF SPECIES

Family TEXTULARIDAE
Genus TEXTULARIA DeFrance

TEXTULARIA RIPLEYENSIS Berry
Plate 41, figures 6–8

Textularia ripleyensis WILLARD BERRY, *1929*, in Berry and Kelley, U. S. Nat. Mus., Proc., vol. 76, Art. 19, p. 4, pl. 2, fig. 2.—CUSHMAN, *1931*, Tenn. Geol. Surv., Bull. 41, p. 19, pl. 1, figs. 6, 7.

Test much compressed, initial portion slightly bulbous in shape, apertural end wide and flattened on top, margin sharp, serrate; chambers

[5] Egger, *Abh. d. II. Cl. d. k. Akad. d. Wiss.* XXI, Bd. I, Abth. 1893.

numerous, 8–9 on each side, low, long, somewhat inflated, overlapping slightly at the middle of the test, sloping downward and laterally from the axis, tapering to the outer end which is frequently projecting; sutures deeply impressed, usually indented at the margin; wall finely arenaceous; aperture a small arched opening at the base and inner end of the last-formed chamber with a short lobe on each side. Length of illustrated specimen, 0.75 mm.

Genus BIGENERINA d'Orbigny

BIGENERINA RIPLEYENSIS Sandidge, n. sp.

Plate 41, figures 4, 5

Test elongate, later portion cylindrical, early part compressed, made up of several biserial chambers, wider than earliest uniserial portion, later chambers increasing slightly in size as added; sutures indistinct both in later portion and in the early biserial part; wall coarsely arenaceous, rough; aperture a terminal, rounded opening in the last chamber. Length of the holotype, 1.3 mm.

Family VERNEUILINIDAE

Genus GAUDRYINA d'Orbigny

GAUDRYINA PUPOIDES d'Orbigny

Plate 41, figure 1

Gaudryina pupoides D'ORBIGNY, *1840*, Mém. Soc. géol. France, vol. 4, p. 44, pl. 4, figs. 22–24; *1846*, Foram, foss. Bassin tert. Vienne, p. 197, pl. 21, figs. 34–36.—CHAPMAN, *1926*, New Zealand Geol. Surv., Pal. Bull. 11, p. 34, pl. 8, fig. 6.

Test elongate, somewhat conical, tapering from a broad and rounded apertural end to a rather sharply pointed initial end, slightly twisted, early triserial portion short and somewhat rounded, later biserial part inflated, only slightly compressed; chambers in triserial portion small, rounded, biserial series gradually increasing in size as added and becoming more inflated, last pair large and much inflated; sutures in early stages indistinct, later becoming definite and deeply impressed; wall coarsely arenaceous, very smoothly finished; aperture a narrow, rectangular slit at the base and inner edge of the last-formed chamber. Length of illustrated specimen, 0.8 mm.

GAUDRYINA OXYCONA Reuss

Plate 41, figures 2, 3

Gaudryina oxycona REUSS, *1860*, Sitz, Akad. Wiss. Wien, vol. 40, p. 229, pl. 12, figs. 3a–c.—CUSHMAN AND CHURCH, *1929*, Proc. Calif. Acad. Sci., ser. 4, vol. 18, p. 501, pl. 56, figs. 3, 4.—CUSHMAN, *1931*, Jour. Pal., vol. 5, p. 300, pl. 34, figs. 4a, b.

Test short, conical, rounded at the initial end, circular in section; chambers triserial in early stages only, biserial chambers flat and wedge-shaped, semicircular in plane view; wall rather thick, coarsely arenaceous smoothly finished; aperture a narrow slit situated in an elongate indentation at the middle of the inner margin of the last chamber. Length of the illustrated specimen, 0.6 mm.

GAUDRYINA STEPHENSONI Cushman

Plate 41, figures 13, 14

Gaudryina stephensoni CUSHMAN, *1928* Contr. Cush. Lab. for Foram. Res., vol. 4, pt. 4, p. 108, pl. 16, figs. 6–8; *1931* Tenn. Geol. Surv., Bull. 41, p. 20, pl. 1, figs. 11a, b.

Test elongate, tapering, tooth-like, sides flattened or slightly concave, angles sharp, marked by a row of small fistulae, initial end pointed,

sometimes curved, tripyramidal, apertural end rather broad and flattened or very slightly arched; chambers numerous, 8 to 10, first 3 or 4 triserial, later ones biserial, wedge-shaped, overlapping, quadrate in section; sutures sometimes slightly impressed, usually indistinct; wall finely arenaceous, smooth except along the lateral angles, which are jagged due to broken fistulose processes; aperture at the inner edge of the last-formed chamber, small, round, not protruding. Length of figured form, 0.6 mm.

This species was originally described by Cushman from the Taylor formation of Texas, and has since been found by him in the Selma chalk of Tennessee. Present knowledge indicates that the form is confined to the lower and middle portion of the Ripley formation in Alabama.

Genus HETEROSTOMELLA Reuss

HETEROSTOMELLA CUNEATA Sandidge, n. sp.

Plate 41, figures 11, 15, 16

Test elongate, tapering, cuneiform, sides flattened or slightly concave, initial end pointed, tripyramidal, apertural portion quadrilateral, apertural face broad and slightly arched, angles marked by a row of small fistulae; chambers variable in number, eight in the holotype, first few triserial, later ones becoming biserial, low, flat; sutures not clearly defined, sometimes slightly impressed; wall finely arenaceous, surface irregular; aperture terminal, located near the middle of the last-formed chamber, small, round, with a short tube-like neck. Length of holotype, 0.45 mm.

This species is very similar to *Gaudryina stephensoni* Cushman[6] of the same fauna, and bears a superficial resemblance to some of the Bolivinitas. The siphon-like character of the aperture distinguishes it from the former, while this feature, together with the triserial early chambers, the jagged appearance of the angles, and the arenaceous character of the test make differentiation easy in the latter case.

This new *Heterostomella* has been found in the lower part of the Ripley formation at Barton's Bluff on Tombigbee River and in the upper Ripley at Prairie Bluff on Alabama River. It occurs frequently at the former locality but only rarely at Prairie Bluff. The holotype is from Barton's Bluff (Locality 53).

Genus CLAVULINA d'Orbigny

CLAVULINA PARISIENSIS d'Orbigny

Plate 41, figure 12

Clavulina parisiensis D'ORBIGNY, *1826*, Modèle, No. 66.—TERQUEM, *1882*, Mém. Soc. géol. France, ser. 3, vol. 2, p. 121, pl. 12 (20), figs. 34a, b.—H. B. BRADY, *1884*, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 395, pl. 48 figs. 14–18.—EGGER, *1893*, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, p. 274, pl. 6, fig. 44.—FLINT, *1897*, Ann. Rep. U. S. Nat. Mus., p. 289, pl. 35, figs. 2, 3.—CUSHMAN, *1911*, U. S. Nat. Mus., Bull. No. 71, p. 75, figs. 123–124 (text); *1921*, U. S. Nat. Mus., Bull. No. 100, p. 156, pl. 19, fig. 4.

Test elongate, slender, triserial in early portion, sharply angled, pointed, later portion uniserial, cylindrical, increasing gradually in size to the last few chambers which may

[6] Cushman, J. A., *Contr. Cush. Lab. Foram. Research*, vol. 4, pt. 4, p. 108, pl. 16. figs. 6–8, 1928.

be slightly inflated; chambers numerous, number variable; sutures in early part indistinct, in later portion distinct and impressed; wall coarsely arenaceous, surface usually rough; aperture round, central, terminal on face of last-formed chamber; with small valve or tooth. Length of figured specimen, 1.5 mm.

The Ripley representatives of this species appear to be somewhat coarser in texture, and to have chambers slightly larger than most specimens figured in the literature. In other respects this Ripley test follows closely the type. So far as is now known, its occurrence is limited to the lower and middle portion of the formation in the Alabama River section, where it is fairly abundant.

CLAVULINA PLUMMERAE Sandidge, n. sp.
Plate 41, figures 17, 18

Test elongate, triangular in early stages, rounded in final stages, tapering at the round apertural end and at pointed initial end, sides approximately parallel in intermediate portion; chambers triserial in early stages, uniserial in later stages; angles in early chambers sharply carinate, less sharp on intermediate chambers, final chambers non-carinate and rounded; sutures indistinct

EXPLANATION OF PLATE 41

FIGS. 1—*Gaudryina pupoides* d'Orbigny, ×45. Specimen from Rocky Bluff, Locality 88. Side view, showing inflation of chambers.

2, 3—*Gaudryina oxycona* Reuss, ×45. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 2, Side view, showing conical shape of test and wedge-shaped chambers. 3, Top view, showing position of aperture and circular cross-section.

4, 5—*Bigenerina ripleyensis* Sandidge, n. sp., ×45. Specimens from exposure at the mouth of Boguechitto Creek, Locality 106. 4, Longitudinal section, showing early biserial and later uniserial arrangement of chambers. 5, Exterior of the holotype, showing large size and rough character of the test.

6, 7, 8—*Textularia ripleyensis* Berry, ×40. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 6, Side view, illustrating inflation of the chambers. 7, View from above, showing cross-sectional shape. 8, Edge view, showing position and character of the aperture.

9, 10—*Dorothia bulletta* (Carsey), ×36. Specimen from exposure at the mouth of Boguechitto Creek. 9, Edge view, showing apertural face. 10, Side view, illustrating inflation of the test.

12—*Clavulina parisensis* d'Orbigny, ×28. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

13, 14—*Gaudryina stephensoni* Cushman, ×40. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 13, Edge view, showing aperture. 14, Side view, illustrating the fistulose angles.

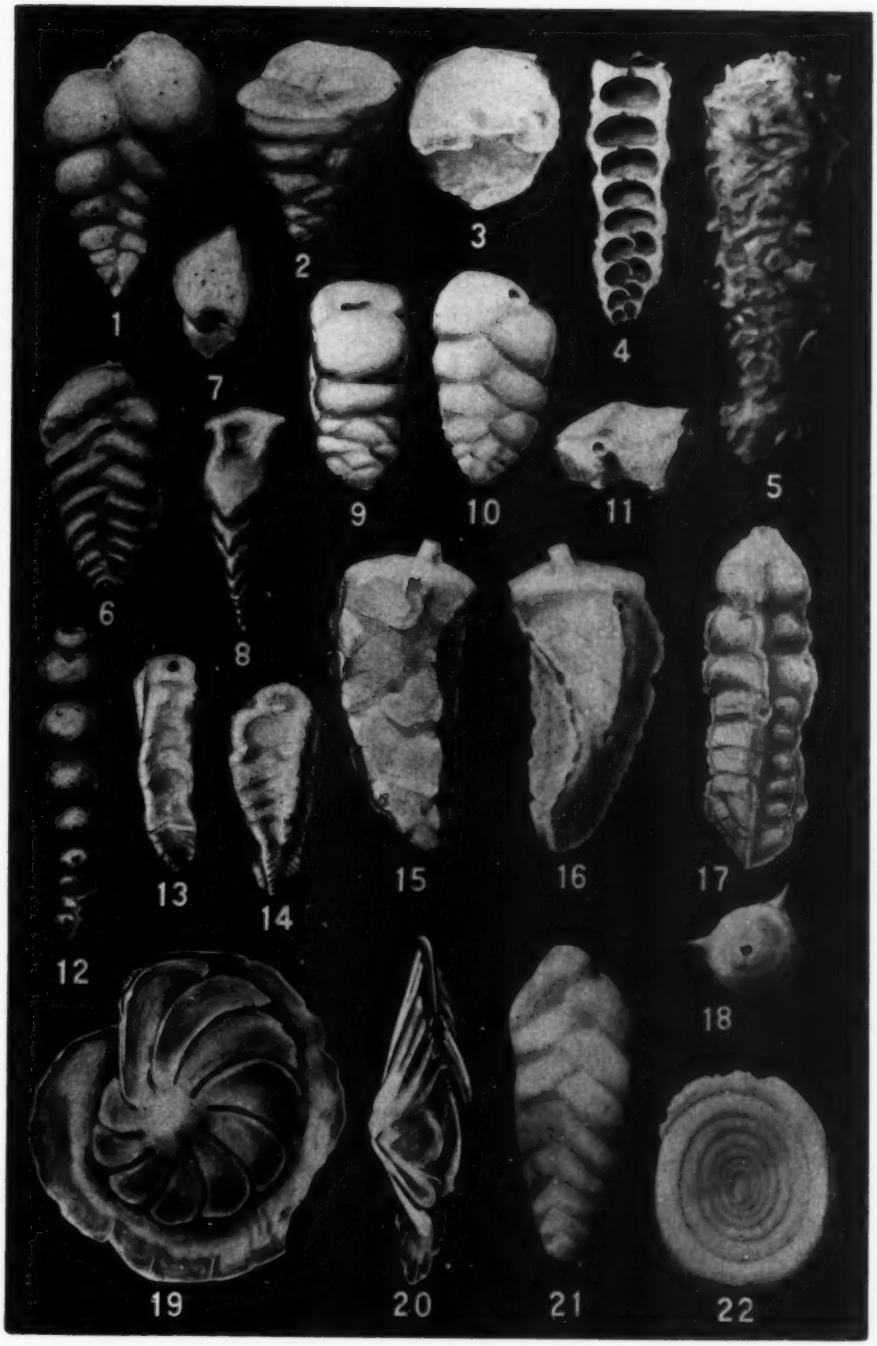
11, 15, 16—*Heterostomella cuneata* Sandidge, n. sp., ×90. Holotype from Barton's Bluff, Locality 53. 11, Top view, giving cross-sectional shape, and position of aperture. 15, View from back, showing flat wall. 16, Front view, illustrating triserial-biserial arrangement, and fistulose angles.

17, 18—*Clavulina plummerae* Sandidge, n. sp., ×28. Holotype from Barton's Bluff, Locality 53. 17, Side view, showing rounded and inflated final chamber. 18, End view, giving cross-sectional shape and character of aperture.

19, 20—*Robulus cultratus* Montfort, ×28. Specimen from Red Bluff, Locality 105. 19, Side view, illustrating wide keel. 20, Peripheral view, showing aperture.

21—*Bolivina incrassata* Reuss, ×45. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

22—*Cornuspira cretacea* Reuss, ×40. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.



Sandidge, Cretaceous Foraminifera

in early portion of test, slightly arched in first uniserial stages, later becoming horizontal and deeply impressed; wall finely arenaceous, rather smoothly finished; aperture rounded, central and terminal on last chamber. Length of the illustrated holotype, 1.6 mm.

This species differs from *Clavulina insignis* Plummer, or *C. trilatera* Cushman, in having its later chambers, particularly the final one, inflated and non-carinate, and the sides of the middle portion of the test practically parallel. It also has an aperture which is consistently rounded, and not trifurcate.

Description of the species is based on specimens which came from Barton's Bluff, on Alabama River (Locality 53). It is named for Helen Jeanne (Mrs. F. B.) Plummer.

Family VALVULINIDAE

Genus DOROTHIA Plummer

DOROTHIA BULLETTA (Carsey)

Plate 41, figures 9, 10

Gaudryina bulletta CARSEY, *1926*, Univ. of Texas, Bull. 2612, p. 28, pl. 4, fig. 4.
Dorothia bulletta PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 132, pl. 8, figs. 13–17.

Test short, stout, nearly circular in horizontal section, initial end conical, ultimate end slightly compressed; chambers in early stages coiled, four or more chambers in a whorl, later three chambers to a whorl, and finally a biserial arrangement is assumed; sutures fine and indistinct in early portion of test, impressed between later chambers; wall smoothly arenaceous; aperature elongate, slightly arched, at the inner edge of the base of the last chamber. Length of illustrated specimen, 0.75 mm.

Family OPTHALMIDIIDAE

Genus CORNUSPIRA Schultze

CORNUSPIRA CRETACEA Reuss

Plate 41, figure 22

Cornuspira cretacea REUSS, *1862–1863*, Sitz. Akad. Wiss. Wien, vol. 46, p. 34, pl. 1, fig. 10.—EGGER, *1899*, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, p. 18, pl. 22, figs. 1, 2.—CUSHMAN, *1926*, Bull. Am. Assn. Petroleum Geol., vol. 10, p. 608, pl. 21, figs. 3a, b.—WHITE, *1928*, Jour. Pal., vol. 2, p. 188, pl. 27, fig. 9.—CUSHMAN, *1931*, Tenn. Geol. Surv., Bull. 41, p. 24, pl. 2, fig. 7.
Cornuspira involvens WILLARD BERRY, *1929*, in Berry and Kelley, U. S. Nat. Mus., Proc., vol. 76, art. 19, p. 15, pl. 1, fig. 15.

Test composed of a long tube, closely coiled around the proloculum, increasing in size with length; oval in shape, bilaterally symmetrical, concave at the center; wall smooth, white; aperture at the end of the tube. Diameter of figured specimen, 0.75 mm.

Family LAGENIDAE

Genus ROBULUS Montfort

ROBULUS CULTRATUS Montfort

Plate 41, figures 19, 20

Robulus cultratus MONTFORT, *1808*, Conch. Syst., vol. 1, p. 214, 54 genre.
Robulina cultrata D'ORBIGNY, *1826*, Ann. Sci. Nat. vol. 7, p. 287, No. 1; *1846*, Foram. Foss. Bass. Tert. Vienne, p. 96, pl. 4, figs. 10–13.
Cristellaria cultrata CHAPMAN, *1926*, New Zealand Geol. Surv., Pal. Bull. 11, p. 61, pl. 1, fig. 6; pl. 4, figs. 9a, b, 15a, b, 27a, b, 30a, b, 31.

Test close-coiled, compressed, umbonate, periphery bearing a thin, broad, nearly transparent keel; chambers numerous, 12 or more in the last-formed coil, narrow, slightly

curving, somewhat overlapping; sutures appearing as narrow curving lines, radiation from a large central boss, usually not raised above the surface of the test; wall smooth, polished, thin, umbilical area covered with a large knob of transparent shell material; apertural face triangular, usually with a narrow rim at the sides; aperture at the peripheral angle, outer edge usually radiate, a slit extending well down into the apertural face. Diameter of illustrated form, 1.5 mm.

The well-preserved specimens of this species from the Ripley formation correspond quite closely to many of the figures in the literature. They are strikingly similar to the European forms figured by d'Orbigny and Reuss. The resemblance to *Cristellaria iota* Cushman[7] is very evident, but the two are distinguished on the basis of size and apertural characterization. Mrs. Plummer's *Cristellaria navarroensis* is regarded as a close relative. *Robulus cultratus* differs from it in being usually larger, in having more chambers, and a much wider keel.

ROBULUS ALDRICHI Sandidge, n. sp.
Plate 42, figures 3, 4

Test close-coiled, somewhat elongate, moderately compressed, umbonate, peripheral margin distinct, bordered by a narrow rim, chambers gently curving, 8 or 9 in last whorl, sutures limbate in early part of coil, later becoming smooth, curving outward from central boss; wall smooth; apertural face flat, triangular, bordered by a narrow rim; aperture at the apical angle, oval, with a few radial striations around the peripheral edge, lower portion extending into the apertural face. Diameter of holotype, 0.7 mm.

This remarkably characteristic representative of Montfort's early genus is closely related to *Cristellaria degolyeri* Plummer[8] described from the Texas Midway. The rimmed, bead-like periphery, and the very definite variation in the type of the aperture are the chief means of differentiation. This occurrence of the robuline representative in the Ripley leads to speculation regarding the ancestry of the Midway form.

The holotype is from Red Bluff, on the Alabama River (Locality 105).

This species is named for Dr. Truman H. Aldrich, paleontologist at the Alabama Museum of Natural History.

Genus LENTICULINA Lamarck

LENTICULINA IOTA (Cushman)
Plate 42, figures 24, 25

Cristellaria cultrata H. B. BRADY (not Montfort), *1884*, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 550, pl. 70, figs. 4–6.—EGGER, *1893*, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 18, p. 352, pl. 12, figs. 8–10, 24, 25; *1899*, Abh. kön. bay. Akad. Wiss. München, Cl. II, vol. 21, Bd. 1, p. 123, pl. 21, figs. 11, 12.
Cristellaria iota CUSHMAN, *1923*, U. S. Nat. Mus. Bull. No. 104, pt. 4, p. 111, p. 129, fig. 2; pl. 30, fig. 1.

Test close-coiled, compressed, umbonate, the periphery with a broad keel, nearly transparent, 13–15 chambers in the last-formed

[7] Cushman, J. A., *U. S. Nat. Mus.*, Bull. 104, pt. 4, 1923, p. 111, pl. 29, fig. 2; pl. 30, fig. 1.

[8] Plummer, Helen Jeanne, *Univ. Tex.*, Bull. 2644, 1926, p. 97, pl. VII, figs. 7a, b.

coil, narrow; sutures slightly curved, very slightly limbate but not raised above the general surface, umbonal region occupied by a large thickened transparent knob, wall smooth, thin; aperture radiate, at the peripheral angle of the test, those of the early chambers distinct throughout the last formed coil.—*Cushman.*

This description of the Recent form from the Atlantic and Gulf of Mexico applies very aptly to the specimens from the Ripley formation. Diameter of figured specimen, 2.25 mm. The fossil representatives are not so transparent as the Recent ones, and there seems to be somewhat greater limbation of the sutures in these forms. Otherwise they closely resemble the figures of the Recent species.

LENTICULINA JONESI Sandidge, n. sp.
Plate 42, figures 1, 2

Test close-coiled, somewhat longer than broad, periphery acute, sometimes slightly keeled; chambers comparatively few, usually 6 to 8 in the last whorl, slightly curving, somewhat inflated; sutures gently curving lines, sometimes slightly impressed, especially between the last few chambers; wall smooth; apertural face rounded, not sharply truncate, triangular in its general shape; aperture at the peripheral angle, somewhat protruding, radiate. Diameter of holotype, 0.75 mm.

This species has been established to care for the many forms occurring in the Ripley which resemble in their general appearance *L. gibba*, but which cannot be grouped with it because of their persistently different apertural face. Whereas *L. gibba* has a truncate apertural face with a rimmed margin, that of *L. jonesi* is inflated and rounded. It resembles in some respects Cushman's *L. d'orbignyi*, but differs from that form in the shape of the apertural face, in having slightly curving chambers and sutures, and in being smaller. *Robulina subangulata* of Reuss is a closely related species, found in the Cretaceous of Europe, from which the Ripley form is differentiated only by the character of its aperture.

The holotype is from Rocky Bluff, on the Alabama River (Locality 88).

This species is named for Dr. Walter B. Jones, state geologist of Alabama.

Genus DENTALINA d'Orbigny

DENTALINA CONFLUENS Reuss
Plate 42, figure 9

Dentalina confluens REUSS *1861*, (1862), Sitz. d. k. Akad. Wiss., Wien Bd. 44, No. 21, p 335, pl. 7, fig. 5.—CUSHMAN, *1931*, Jour. Pal. vol. 5, p. 304, pl. 35, fig. 1.
Nodosaria confluens EGGER, *1899* (1902) Abh. d. II, Cl. d. k. Akad. Wiss. XXI, Bd. 1, Abth., München, p. 72, pl. 9, figs. 27, 28.

Test elongate, moderately slender, very slightly tapering, a short, stout spine at the aboral end; chambers in early portion of test about as broad as long, nearly uniform in size, later ones longer, slightly inflated, numerous, from 8 to 10; sutures indistinct between early chambers, constricted toward the apertural end of the test; wall ornamented with from 10 to 12 sharp, occasionally discontinuous, longitudinal costae extending from apical spine to aperture, early ones slightly twisted; aperture eccentric, at the end of a tapering neck. Length, 1.2 mm.

DENTALINA REUSSI Neugeboren
Plate 42, figure 10

Dentalina reussi NEUGEBOREN, *1850*, Verhandl. und Mittheil, d. Siebenbürgischen Vereins Nat. Wiss. zu Hermannstadt; *1856*, Denkschr. d. k. Akad. Wiss. Wien, vol. 12, p. 85, pl. 3, figs. 6, 7, 17.—PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 151, pl. 11, fig. 5.
Nodosaria reussi EGGER, *1899*, Abh. d. II, Cl. d. k. Ak. d. Wiss. Bd. 21, Abth. 1, p. 57, pl. 6, fig. 35.

Test elongate, slender, tapering, arcuate, apical end rounded, apertural end slightly inflated; chambers numerous, eight in the type form, earlier chambers small, short, increasing in size very gradually, later ones elongate, slightly inflated, increasing in size as added, sutures straight; aperture slightly eccentric, terminal, radiate. Length of figured form, 1.5 mm.

DENTALINA ALTERNATA (Jones)
Plate 42, figure 6

Nodosaria zippei var. *alternata* JONES, *1884–1885*, in Wright, Proc. Belfast Nat. Field Club, Appendix 9, pt. 4, p. 330, pl. 27, fig. 10.
Nodosaria alternata CARSEY, *1926*, Univ. of Texas, Bull. 2612, p. 35, pl. 4, fig. 7.
Dentalina alternata PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 153, pl. 9, fig. 7.
Nodosaria affinis CUSHMAN, *1931*, Jour. Pal., vol. 5, p. 305, pl. 35, fig. 2 (not 3–5).

Test straight, of uniform diameter, somewhat stout, apertural end rounded, apical end rather blunt, typically with a short, stout spine; chambers cylindrical, short, closely spaced, uninflated except last few, 8 to 10 in number; sutures flush in early stages, later slightly impressed; wall ornamented with sharp costae, extending the length of the test, with lower, less conspicuous costae between them; aperture terminal, protruding, round. Length of illustrated specimen, 1.8 mm.

The figures of this species given by Mrs. Carsey and Mrs. Plummer vary in details, Mrs. Carsey's specimen more closely resembling the original representation of the form in Wright's work. The figured specimen from the Ripley is very similar to the three previously published illustrations, and corresponds particularly well to the picture of the original type, which came from the Cretaceous of Ireland.

DENTALINA CRINITA Plummer
Plate 42, figure 5

Dentalina crinita PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 154, pl. 11, figs. 12, 13.

Test arcuate, elongate, slender, tapering, initial end rounded, apertural end drawn out into a short neck; chambers increasing in size as added, early ones short, of nearly uniform diameter, later ones longer, slightly inflated; surface covered with fine short spines adhering to walls of chambers, less prominent on later chambers; apertures at the end of neck, round. Length of illustrated specimen, 1.8 mm.

DENTALINA PINNIGERA Sandidge, n. sp
Plate 42, figures 11, 12

Test slightly arcuate, of uniform diameter, somewhat stout, apertural end rounded with short projecting apertural neck, initial end blunt with a short stout spine; chambers closely spaced, eight in number, only slightly inflated in early stages, later chambers considerably inflated, last one nearly round; sutures very little impressed in early stages, distinctly constricted between last two or three

chambers; wall ornamented by high fin-like costae extending from end to end of the test with lower, less conspicuous, often discontinuous costae lying between them, the number of each is six; aperture at the end of the protruding neck, round. Length of holotype, 1.4 mm.

This species bears characteristics of *Nodosaria raphanus* (Linnaeus) and of *N. intercostata* Reuss, but it differs from both these forms in being slightly yet consistently arcuate. In addition, the presence of the small intermediate costae removes it from the former, and the very prominent fin-like edges of the principal costae distinguish it from the later species. It also is closely related to *Dentalina alternata* (Jones),[9] but differs from that species in being shorter and stouter, and in having the very wide transparent fins along the main costae. Numerous excellently preserved specimens of *D. pinnigera* occur throughout the upper part of the Ripley in Alabama.

The holotype is from an exposure at the mouth of Boguechitto Creek, on the Alabama River (Locality 106).

Genus NODOSARIA Lamarck

NODOSARIA RADICULA (Linnaeus)

Plate 42, figure 7

Nautilus radicula LINNAEUS, *1767*, Syst. Nat., 12th Ed., p. 1164, No. 285.

Nodosaria radicula H. B. BRADY, *1884*, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 495, pl. 61, figs. 28–31.—FLINT, *1897* (1899), Ann. Rep. U. S. Nat. Mus., p. 309, pl. 55, fig. 1.—EGGER, *1902*, Abh. d. II, Cl. d. k. Ak. Wiss. XXI, Bd. I, Abth, p. 67, pl. 5, fig. 40.—CUSHMAN, *1919*, U. S. Nat. Mus., Bull. No. 100, vol. 4, p. 190, pl. 34, fig. 4; *1913*, U. S. Nat. Mus., Bull. No. 71, pt. 3, p. 52; *1923*, U. S. Nat. Mus., Bull, No. 104, pt. 4, p. 73.—PLUMMER, *1926*. Univ. Tex. Bull. 2644, p. 77, pl. 4, figs. 9a, b; *1931*, Univ. Tex., Bull. 3101, p. 155, pl. 11, figs. 1, 2.—CHAPMAN, *1926*, New Zealand Geol. Surv., Pal. Bull. No. 11, p. 52, p. 3, figs. 12, 14, 15, 19; pl. 11, fig. 9.

Nodosaria larva CARSEY, *1926*, Univ. Tex. Bull. 2612, p. 31, pl. 2, fig. 2.

Test elongate, slightly tapering, initial end rounded, apertural end larger, but drawn out slightly around the aperture; chambers few, compactly arranged; sutures flush and visible as thin lines in early stages, impressed between later chambers; wall smooth, polished; aperture terminal round. Length of illustrated specimen, 0.6 mm.

NODOSARIA ZIPPEI Reuss

Plate 42, figures 13, 14

Nodosaria zippei REUSS, *1845*, Die Versteinerungen der böhemischen Kreid. formation, pt. 1, p. 25, pl. 8, figs. 1–3.—BEISSEL AND HOLZAPFEL, *1891*, Abhandl. d. geol. Landesanstalt, n. Fol., Heft. 3, pp. 31, 32, pt. 6, figs. 10–29, pl. 16, fig. 32.—EGGER, *1899*, Abh. d. II, Cl. d. k. Ak. d. Wiss., Bd. 21, Abth. 1, p. 78, pl. 8, fig. 3.

Nodosaria affinis CUSHMAN, *1931*, Tenn. Geol. Surv. Bull. 41, p. 30, pl. 3, figs. 17–20; *1931*, Jour. Pal., vol. 5, p. 305, pl. 35, figs. 3, 5.—*1932*, U. S. Nat. Mus., Proc., vol. 80, art. 14, p. 34, pl. 10. fig. 13.

Test elongate, apiculate, tapering at the apertural end to the protruding apertural neck, and at the initial end to a short spine; chambers few, usually inflated, in megalospheric form decreasing in size as added, increasing in size in microspheric form; sutures constricted in later stages, septae visible as dark bands between early chambers; wall ornamented with 10 strong, sharp costae extending from the apical spine to the aperture, giving the shell a fluted appearance, indented at the later sutures;

[9] Plummer, Helen Jeanne, Texas, Univ., Bull. 3101, 1931, p. 153, pl. 11, fig. 7.

aperture central, radiate, protruding. Length of the illustrated specimens: microspheric form, 2.25 mm.; megalospheric, 1.3 mm.

Reference of this Ripley form to *Nodosaria zippei* is based primarily on the original description and figures of the species as given by Reuss.[10] The description, freely translated, is as follows:

> This important species, which sometimes reaches a length of 1.5 inches, is seldom preserved whole because of its fragilty. It is straight, composed of 20–30 chambers, inflated in the upper part of the test, and separated by broad, deep constrictions. In the lower part of the test these constrictions are less distinct, and the early chambers are only slightly separated by a poorly developed

[10] *Die Versteinerungen der böhmischen Kreide* formation, pt. 1, 1845, p. 25, pl. 8, figs. 1–3.

EXPLANATION OF PLATE 42

FIGS. 1, 2—*Lenticulina jonesi* Sandidge, n. sp., ×38. Holotype from Rocky Bluff, Locality 88. 1, Side view, showing slight inflation of chambers, and convexity of the apertural face. 2, Peripheral view, illustrating the character of the aperture.

3, 4—*Robulus aldrichi* Sandidge, n. sp., ×30. Holotype from Red Bluff, Locality 105. 3, Apertural view, showing flatness of apertural face, and marginal rim. 4, Side view, illustrating shape and limbation of sutures.

5—*Dentalina crinita* Plummer, ×20. Specimen from Rocky Bluff, Locality 88.

6—*Dentalina alternata* (Jones), ×23. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

7—*Nodosaria radicula* (Linnaeus), ×45. Specimen from Rocky Bluff, Locality 88.

8—*Nodosaria manifesta* (Reuss), ×28. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

9—*Dentalina confluens* Reuss, ×25. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

10—*Dentalina reussi* Neugeboren, ×22. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

11, 12—*Dentalina pinnigera* Sandidge, n. sp., ×23. Holotype from exposure at the mouth of Boguechitto Creek, Locality 106. 11, Cross-sectional view at the top of the last chamber, showing aperture and arrangement of the costae. 12, View showing the transparent, fin-like costae, and general appearance of test.

13, 14—*Nodosaria zippei* Reuss, 13, Megalospheric form, from exposure at the mouth of Boguechitto Creek, Locality 106, ×23. 14, Microspheric form, from Barton's Bluff, Locality 53, ×12.

15, 26—*Frondicularia archiaciana* d'Orbigny, ×22. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 15, Edge view, showing truncate character of margin. 26, Side view, showing flat face and sutures.

16, 17—*Frondicularia cuspidata* Cushman, ×40. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 16, Side view, showing large, fluted proloculum. 17, Edge view, illustrating inflation of proloculum, and compression of test in later stages.

18, 19—*Buliminella cushmani* Sandidge, n. sp. ×80. Holotype from exposure at the mouth of Boguechitto Creek, Locality 106. 18, View of side opposite the aperture, showing spiral sutures. 19, View showing the aperture, gracefully curving sutures, and the smoothness of the test.

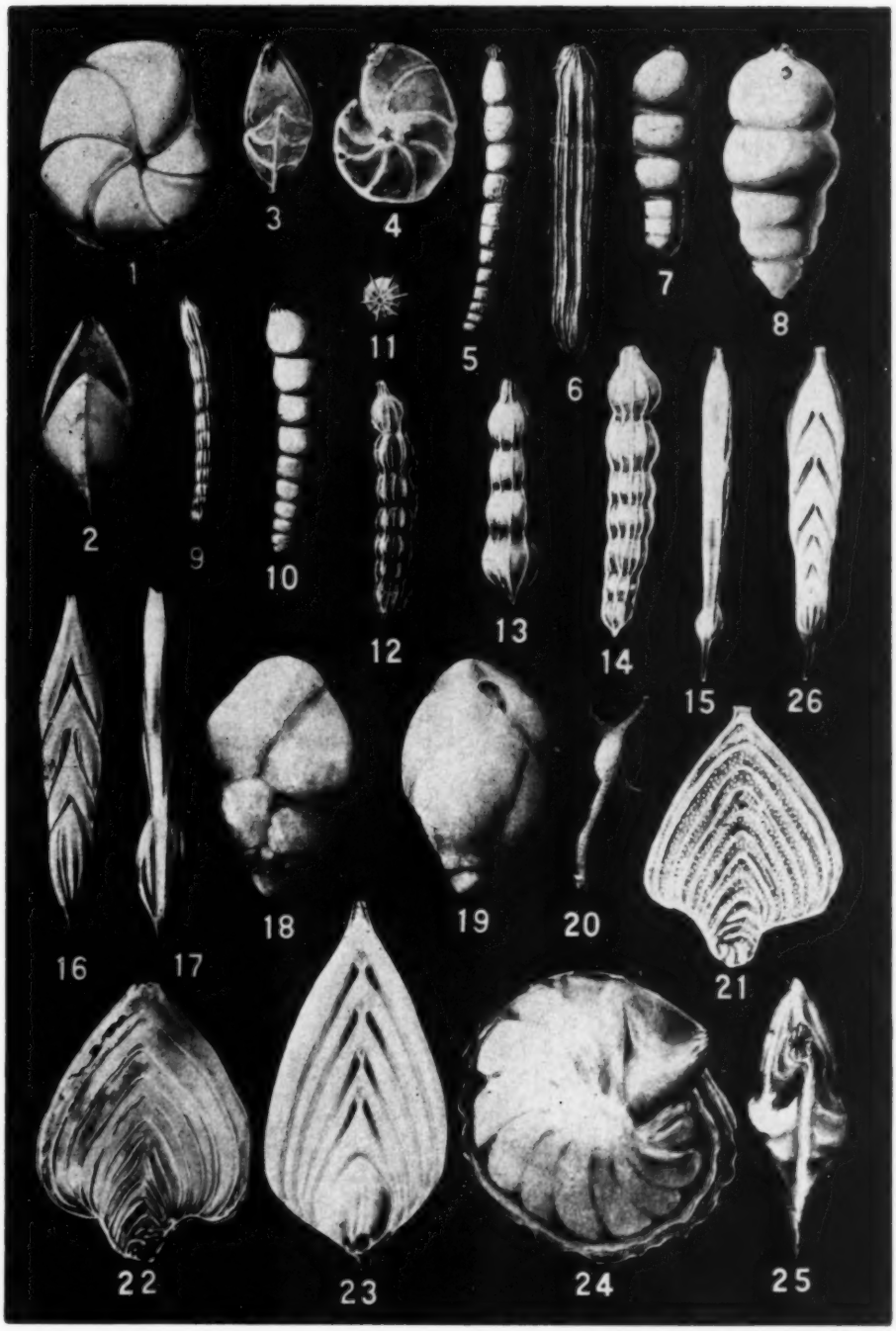
20—*Ramulina globulifera* H. B. Brady, ×22. Specimen from Prairie Bluff, Locality 87.

21—*Flabellina interpunctata* Von der Marck, ×18. Specimen from Rocky Bluff, Locality 88.

22—*Flabellina rugosa* d'Orbigny, ×18. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

23—*Frondicularia trispiculata* Sandidge, n. sp., ×38. Holotype from exposure at the mouth of Boguechitto Creek, Locality 106. The three spines may be seen at the lower extremity of the proloculum.

24, 25—*Lenticulina iota* (Cushman), ×16. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 24, Side view, showing keel. 25, Peripheral view, illustrating the aperture.



Sandidge, Cretaceous Foraminifera

groove. The proloculum is globular, usually somewhat larger than the next adjacent chamber, and has a short spine. Running longitudinally on the chambers there are from 7 to 14 strong, raised, fin-like costae, the number of which is variable on a single individual. Often the number of costae is increased by the insertion of new ones, that is, some of the costae begin and end suddenly. Very rarely two neighboring costae may fuse. Often between two costae one or two long, raised lines, suggesting additional costae, may be seen. The last chamber ends in an elongation on which is found the small, round aperture. The interior of each chamber is entirely round, and communicates with adjacent chambers by a short, cylindrical canal.

Ten years after this description appeared, Reuss,[11] in his discussion of *N. polygona*, indicates that the two forms are similar but that *N. zippei* is distinguished by having a larger number (7–14) of ribs. *N. polygona* has eight ribs. *N. zippei* thus clearly is a form with many costae.

The Ripley specimens, it is true, are much smaller than Reuss's largest representatives, but in all essential structural details they closely resemble the original type. Beissel has figured and described a series of specimens of this species ranging from a juvenile, single-chambered form to an adult with 20 chambers. The Ripley specimens duplicate practically all the stages Beissel has represented.

This form closely resembles many specimens from the Cretaceous which have been referred to *Nodosaria affinis*, but it is very difficult to reconcile the published figures and descriptions of these representatives with the original description and figures of this species as given by Reuss.[12] A free translation of this description is as follows:

Test 2.5–3 mm. long, very thin, straight, slightly tapering to initial end; from 8 to 9 small, eliptical chambers, separated by distinct constrictions, ornamented with from 4 to 5 high, fin-like, irregular costae, which are reduced at the constrictions. The proloculum is drawn out sharply to a short, hair-like spine. The last chamber is moderately pointed.

Later Reuss[13] points out that *Dentalina baltica* is very similar to *D.* (*Nodosaria*) *affinis*, but that the latter is distinguished by the spine on the first chamber and the smaller number of longitudinal costae. *D. baltica* has from 8 to 9 ribs or costae; so it is clear that in Reuss's mind, *D.* (*N.*) *affinis* was a form possessing very few ribs.

The figured specimens of *N. affinis* from the Coastal Plain in this country possess many more than four or five costae, and these, while they may be somewhat indented where the chambers join, continue across the constrictions. These specimens also have chambers which, as added, vary in size much more than do those of *N. affinis* Reuss. Some confusion undoubtedly has arisen because many forms have been referred to the preoccupied *N. affinis* of d'Orbigny.[14] while it appears that some of the American specimens which have been called *Nodosaria affinis* may be referred to the closely related *N. verte-*

[11] *Zeit. Deut. geol. Ges.*, Bd. 7, 1855, p. 266.

[12] *Die Versteinerungen der böhmischen Kreide formation*, pt. 1, 1845, p. 26, pl. 13, fig. 16.

[13] *Zeit. Deut. geol. Ges.*, Bd. 7, 1855, p. 269.

[14] *Foram. Foss. Vienne*, 1846, p. 39, pl. 1, figs. 36–39.

bralis Batsch,[15] the majority of these forms belong to *N. zippei* Reuss.

NODOSARIA MANIFESTA (Reuss)

Plate 42, figure 8

Glandulina manifesta REUSS, *1851*, Hardinger's Naturw., Abh., Bd. 4, Abth. 1, pl. 2, fig. 4.—EGGER, *1899*, Abh. kön. bay. Akad. Wiss. München Cl. II, vol. 21, Bd. 1, p. 82, pl. 5, figs. 27, 28.

Nodosaria (Glandulina) manifesta, CUSHMAN, *1926*, Bull. Am. Assn. Petroleum Geol., vol. 10, p. 595, pl. 18, fig. 8.

Test elongate, somewhat stout, conical, apertural end rounded, initial end bluntly pointed; chambers inflated, diameter about twice the height, early ones small, increasing in size as added, sutures distinct, constricted between later chambers; wall rather thick, smooth, sometimes retaining the original polish; aperture terminal, central, radiate. Length of illustrated specimen, 0.6 mm.

Genus FRONDICULARIA DeFrance

FRONDICULARIA ARCHIACIANA d'Orbigny

Plate 42, figures 15, 26

Frondicularia archiaciana D'ORBIGNY, *1840*, Mém. Soc. Géol. France, vol. 4, p. 20, pl. 1, figs. 34–36.—REUSS, *1845*, Verst. böhm. Kreidef., pt. 1, p. 31, pl. 13, fig. 29.—CHAPMAN, *1894*, Jour. Roy. Mic. Soc., p. 154, pl. 3, fig. 6.—EGGER, *1899*, Abh. kön. bay. Akad. Wiss., München, Cl. II, vol. 21, Bd. 1, p. 87, pl. 10. fig. 19.—CUSHMAN, *1930*, Contr. Cush. Lab. Foram. Res., vol. 6, pt. 2, p. 37, pl. 5, figs. 9–12; *1931*, Tenn. Geol. Surv., Bull. 41, p. 35, pl. 4, figs. 13a, b.

Test elongate, evenly compressed, slightly wider near the apertural end than at the initial end, rectangular in transverse section, sides cut squarely; chambers few from 6 to 8 in number, large, initial one spherical, bearing an apical spine and three or four distinct longitudinal costae, later chambers chevron-shaped, increasing in size as added, last one drawn out into a neck bearing the aperture; sutures distinct, raised into narrow ridges, forming inverted V's; wall smooth except in early stages when the surface is marked by a few discontinuous, longitudinal striations; aperture terminal, produced, round, radiate. Length of illustrated specimen, 2.1 mm.

[15] *Conch. des Seesandes*, 1791, p. 3, No. 6, pl. 2, fig. 6.

FRONDICULARIA CUSPIDATA Cushman

Plate 42, figures 16, 17

Frondicularia cuspidata CUSHMAN, *1931*, Tenn. Geol. Surv., Bull. 41, p. 36, pl. 5, figs. 4, 5.

Test elongate, slender, widest at the base of the last-formed chamber, tapering gracefully to a long, pointed spine on the base of the proloculum an elongate, fusiform chamber, with five equally spaced, longitudinal striae visible on each face; later chambers flat, of elongate-chevron shape, edges truncate with sharp angles; sutures slightly raised, open at the top, ornamented with exceedingly fine, longitudinal striae; aperture at the apex of the last chamber. Length of the illustrated specimen, 1.2 mm.

FRONDICULARIA TRISPICULATA Sandidge, n. sp.

Plate 42, figure 23

Test flat, sagitate, elongate, widest across the face at the level of the aperture of the proloculum, sides curving, sloping gradually to the aperture of the last chamber, and abruptly to the base of the prolocu-

lum; proloculum pear-shaped, bearing two closely spaced costae on each face which extend from its aperture to the base where they fuse to form a small, short spine on either side; a single strong spine extends downward from the bottom of the test between the small spines; later chambers are chevron-shaped, gracefully curving from aperture to the lower ends, tapering downward, sides truncate; sutures slightly elevated, rounded, open at the top; apertures of early chambers visible between upper ends of sutures, final aperture slightly radiate, small, round, protruding. Length of the holotype, 1.3 mm.

This new species resembles in its general characteristics *F. goldfussi* Reuss, but is easily distinguished by the sharply truncate margin, the pattern of the sutures, and the presence of the three spines at the base of the test. There is some similarity to *F. alata* d'Orbigny, and to *F. gaultina* Reuss, although the new species is very distinctive in its detailed structure.

F. trispiculata occurs rarely in the lower Ripley in the western and central parts of Alabama. The holotype is from exposures at the mouth of Boguechitto Creek, on Alabama River (Locality 106).

Genus FLABELLINA d'Orbigny

FLABELLINA RUGOSA d'Orbigny

Plate 42, figure 22

Flabellina rugosa D'ORBIGNY, *1840*, Mém. Soc. Géol. France, ser. 3, vol. 4, pt. 1, p. 23, pl. 2, figs. 4, 5, 7.—REUSS, *1845–46*, Verstein. bohm. Kreidef. p. 33, pl. 8, figs. 31–35, pl. 13, figs. 49–53.—PLUMMER, *1931*, Univ. Tex., Bull. 3101, p. 166, pl. 12, fig. 4.—CUSHMAN, *1931*, Jour. Pal., vol. 5, p. 307, pl. 35, fig. 10.

Frondicularia rugosa PLUMMER, *1926*, Univ. Tex., Bull. 2644, p. 118, pl. 5, fig. 1; text fig. 13.

Test rhomboidal in shape, compressed, margins truncate, extremities drawn out, the initial end somewhat obtuse; chambers numerous, narrow, chevron-shaped; sutures raised, earlier ones forming semicircles at the crest of each chamber; aperture terminal, round, small. Length of illustrated specimen, 2.1 mm.

FLABELLINA INTERPUNCTATA Von der Marck

Plate 42, figure 21

Flabellina interpunctata VON DER MARCK, *1858*, Verh. nat. Ver. preuss. Rheinl., vol. 15, p. 53, pl. 1, fig. 5.—REUSS, *1860*, Sitz. Akad. Wiss. Wien, vol. 40, p. 216, pl. 9, fig. 1.—WHITE, *1928*, Jour. Pal., vol. 2, p. 204, pl. 29, fig. 1.—CUSHMAN, *1930*, Contr. Cush. Lab. Foram. Res., vol. 6, pt. 2, p. 30, pl. 4, figs. 16, 17; *1931*, Jour. Pal., vol. 5, p. 307, pl. 35, fig. 9.—PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 163, pl. 12, figs. 1–3.

Flabellina rugosa BEISSEL, *1891*, Abhandl. Kön. Preuss. geol. Landes., N. Fol., vol. 3, p. 47, pl. 9, figs. 20–24.

Test flat, compressed, generally rhomboid in outline, periphery truncate; chambers coiled in early stages, later ones extending down on either side in the plane of coiling; sutures raised, sharp, often with loop-like structures at the tops of the chambers; wall between the sutures ornamented with numerous small papillae; aperture at the end of a short projection on the last chamber. Length of illustrated specimen, 1.6 mm.

Family POLYMORPHINIDAE

Genus RAMULINA Rupert Jones

RAMULINA GLOBULIFERA H. B. Brady

Plate 42, figure 20

Ramulina globulifera H. B. BRADY, *1884*, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 587,

pl. 76, figs. 22–28.—CUSHMAN, *1927*, Contr. Cush. Lab., vol. 3, pt. 1, p. 48, pl. 9, fig. 19.—PLUMMER, *1931*, Univ. Tex., Bull. 3101, p. 174, pl. 10, fig. 15.

Test free, branching, composed of a subglobular chamber with a connecting stoloniferous tube and several radiating tubules; wall hyaline, surface marked by sparcely set spines; apertures tubular. Length of illustrated specimen, 1.2 mm.

Family BULIMINIDAE

Genus BULIMINELLA Cushman

BULIMINELLA CUSHMANI Sandidge, n. sp.

Plate 42, figures 18, 19

Test small, compactly fusiform, spirally coiled, involute, circular in transverse section, the initial end pointed, apertural end tapering more gradually and rounded at the top; chambers numerous, four in the last whorl, slightly inflated; sutures impressed; wall smooth, finely perforate, thin; aperture a comma-like opening at the end of the last chamber, extending from near the apex down to the last whorl. Length of holotype, 0.4 mm.

This species is very similar to *Buliminella carseyae*,[16] but differs from it in being smaller and more compact. Also the chambers are less inflated, and the sutures curve more gracefully than in *B. carseyae*.

The holotype of the species came from the exposure at the mouth of Boguechitto Creek (Locality 106).

This species is named for Dr. Joseph A. Cushman, Sharon, Massachusetts.

[16] Plummer, Helen Jeanne, *Texas. Univ.* Bull. 3101, 1931, p. 179, pl. 8, fig. 9.

Genus BULIMINA d'Orbigny

BULIMINA PUPOIDES d'Orbigny

Plate 43, figure 1

Bulimina pupoides D'ORBIGNY, *1846*, Foram. Foss. Vienne, p. 185, pl. 11, figs. 11, 12.—H. B. BRADY, *1884*, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 400, pl. 50, figs. 15a, b.—EGGER, *1902* (1899). Abh. d. II, Cl. d. k. Ak. d. Wiss. XXI, Bd. I, abth.,—CUSHMAN, *1911*, U. S. Nat. Mus., Bull. No. 71, p. 80, fig. 132.—PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 180, pl. 9, fig. 15.

Test oval in shape, somewhat pointed at apical end, rounded at the apertural end, slightly tapering; chambers numerous, early ones small, the last few increasing rapidly in size, inflated, all arranged triserially; sutures indistinct in early portion of test, slightly depressed and easily visible between later chambers; wall smooth, thin, perforate, aperture a narrow slit extending obliquely downward from apex of last chamber. Length of illustrated specimen, 0.4 mm.

BULIMINA SUBORNATA Brady

Plate 43, figure 2

Bulimina subornata BRADY, *1884*, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 402, pl. II, figs. 6a, b.—CUSHMAN, *1911*, U. S. Nat. Mus., Bull. No. 71, p. 88, fig. 141.

Test oval in shape, tapering slightly from the apertural end to the initial end, pointed at the initial end, which bears a short spine, rounded at the apertural end; chambers numerous, arranged triserially, increasing in size as added, last few somewhat inflated; early chambers ornamented with fine, raised longitudinal costae; wall thin, perforate; aperture a narrow slit extending downward obliquely from the apex of the last chamber.

Length of the illustrated specimen, 0.4 mm.

BULIMINA ELONGATA d'Orbigny
Plate 43, figure 3

Bulimina elongata D'ORBIGNY, *1846*, For. Foss. Vienne, p. 187, pl. 21, figs. 19, 20.—H. B. BRADY, *1884*, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 401, pl. 51, figs. 1, 2.—CUSHMAN, *1911*, U. S. Nat. Mus., Bull. No. 71, p. 79, fig. 131.

Test elongate, nearly cylindrical, slightly pointed at apical end, rounded at oval end; chambers numerous, increasing in size very gradually from initial portion, inflated, short; sutures distinct, depressed; wall smooth, very finely punctate, thin, aperture a vertical elongate opening at inner edge of last chamber. Length of illustrated specimen, 0.45 mm.

Genus BOLIVINA d'Orbigny

BOLIVINA INCRASSATA Reuss
Plate 41, figure 21

Bolivina incrassata REUSS, *1851*, Hardinger's Nat. Abh., vol. 4, p. 29, pl. 4, fig. 13; *1861*, (1862), Sitz. Akad. Wiss. Wien. vol. 44, pt. 1, p. 332.—CUSHMAN, *1926*, Contr. Cush. Lab., vol. 2, p. 19, pl. 2, figs. 1a, b; Idem. p. 86, pl. 12, figs. 1a, b; *1927*, Jour. Pal., vol. 1, p. 161, pl. 28, fig. 11; *1931*, Tenn. Geol. Surv., Bull. 41, p. 49, pl. 8, figs. 2–4; *1931*, Jour. Pal., vol. 5, p. 310, pl. 35, figs. 17a, b.

Test stout, laterally compressed, slightly tapering, widest at apertural end, proloculum inflated in megalospheric form, pointed in microspheric form; chambers numerous, low, slightly inflated; sutures impressed, oblique, distinct; wall smooth, finely punctate; aperture elongate, extending downward along shorter edge of last chamber from the apex to its base. Length of illustrated specimen, 0.9 mm.

Family ROTALIIDAE

Genus DISCORBIS Lamarck

DISCORBIS CORRECTA Carsey
Plate 43, figures 7–9

Discorbis correcta CARSEY, *1926*, Univ. of Texas, Bull. 2612, p. 45, pl. 3, figs. 5a, b.—PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 188, pl. 14, figs. 1–4.

Test generally oval in outline, dorsal face somewhat convex, ventral face slightly concave, umbilicate; peripheral margin thin but rounded; chambers curving, increasing in size rather rapidly, usually 8 in last whorl, surface distinctly punctate; sutures on both sides curved, flush with surface in early stages, sharply impressed between later chambers; aperture a well defined slit extending from the ventral margin under an apertural lip into the small excavated umbilical depression. Diameter of illustrated specimen, 0.3 mm.

Genus VALVULINERIA Cushman

VALVULINERIA RIPLEYENSIS Sandidge, n. sp.
Plate 43, figures 4–6.

Test oval, biconvex, somewhat flattened on the dorsal side, ventral side strongly convex, periphery broadly rounded, umbilical cavity deep; chambers numerous, all visible dorsally, 7 to 8 in the last whorl, increasing in size rapidly, last few inflated, with a V-shaped flap extending into the umbilical cavity; sutures distinct, later ones deeply impressed; wall smooth, coarsely punctate; aperture an elongate opening extending from the periphery into the umbilical area, partially covered by the umbilical flap of the last chamber. Diameter of the holotype, 0.6 mm.

The holotype is from Ripley exposures at the mouth of Boguechitto Creek (Locality 106).

Genus GYROIDINA d'Orbigny

GYROIDINA SOLDANII D'ORBIGNY

Plate 43, figures 10–12

Gyroidina soldanii D'ORBIGNY, *1826*, Ann. Sci. Nat., vol. 7, p. 278, No. 5,

Rotalia soldanii BRADY, *1884*, Rep. Voy. *Challenger*, Zoology, vol. 9, p. 706, pl. 107, figs. 6, 7.—EGGER, *1893*, Abh. kön. bay. Akad. Wiss., München, Cl. II, vol. 18, p. 420, pl. 19, figs. 16–18, 51; *1899*, Abh. kön. bay. Akad. Wiss., München, Cl. II, vol. 21, p. 156, pl. 20, figs. 26, 27, 28.—CUSHMAN, *1915*, U. S. Nat. Mus., Bull. No. 71, pt. 5, p. 71, pl. 29, fig. 1; *1921*, pl. 31, fig. 4; U. S. Nat. Mus., Bull. No. 100, vol. 4, p. 349, pl. 71, figs. 2a–c.—CHAPMAN, *1926*, New Zealand Geol. Surv., Pal. Bull. No. 11, p. 86, pl. 5, figs. 23a–c, 24a–c.

Test plano-convex, dorsal side flat or slightly convex with a spiral depression marking the boundary of each whorl, ventral side strongly convex, a small umbilical cavity at the center; chambers numerous, distinct, narrow, elongate, curving in the axial plane; sutures on ventral side smooth or only slightly impressed, distinctly impressed on the dorsal side, especially around the periphery; wall smooth, thick, finely perforate; aperture a narrow, elongate slit extending from near the periphery almost to the umbilicus along the margin of the last-formed chamber. Diameter of illustrated specimen, 0.35 mm.

The representatives of *G. soldanii* found in the Ripley formation, though not so acutely angular at the periphery as d'Orbigny's models indicate his specimens were, nevertheless correspond very closely to the figures of Brady, Egger, Chapman, and Cushman.

EXPLANATION OF PLATE 43

FIGS. 1—*Bulimina pupoides* d'Orbigny, ×75. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

2—*Bulimina subornata* Brady, ×85. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106.

3—*Bulimina elongata* d'Orbigny, ×75. Specimen from Red Bluff, Locality 105.

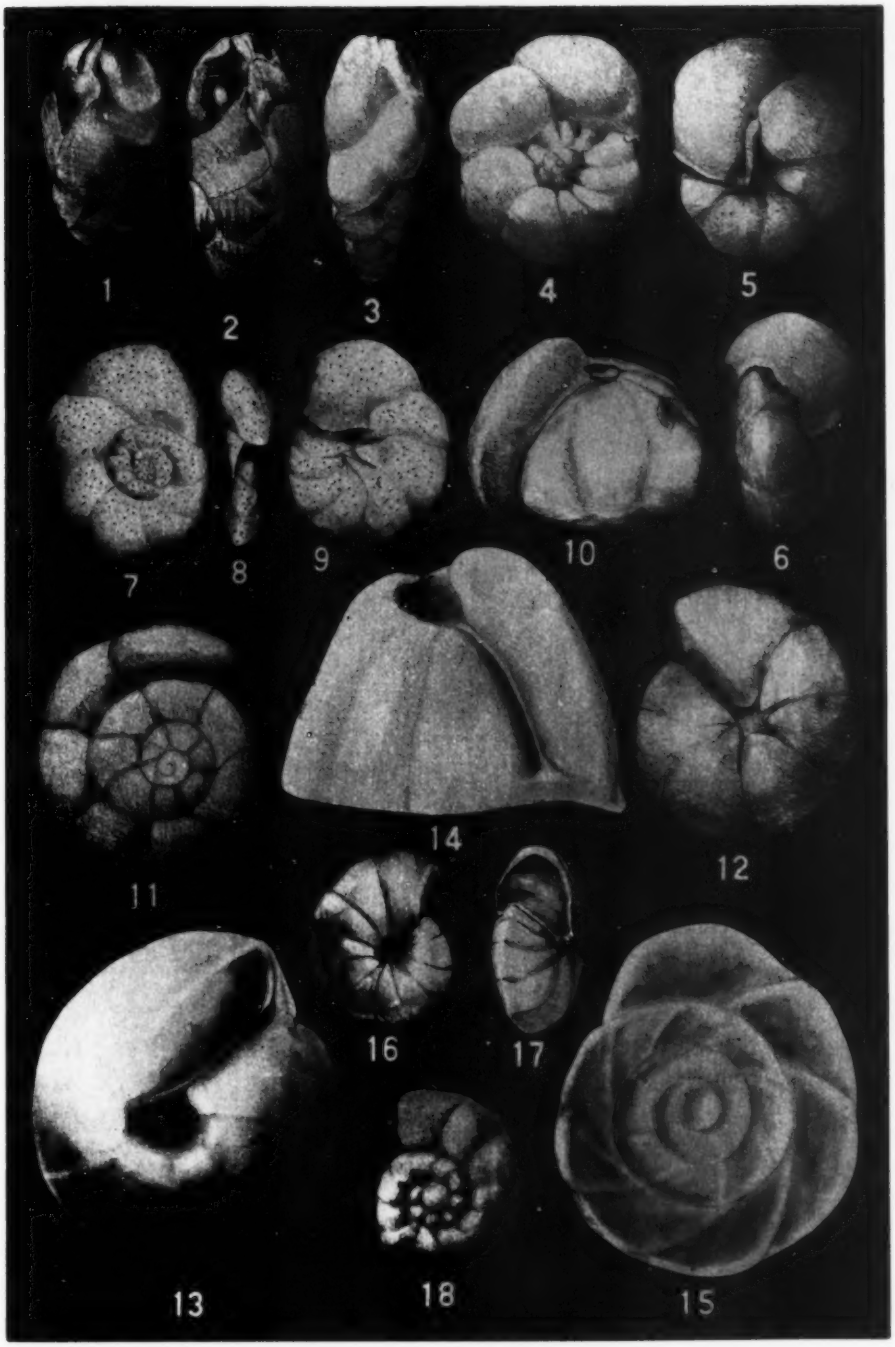
4, 5, 6—*Valvulineria ripleyensis* Sandidge, n. sp., ×50. Holotype from exposure at the mouth of Boguechitto Creek, Locality 106. 4, Dorsal view, showing early coils 5, Ventral side, illustrating prominent flap extending over umbilical area. 6, Peripheral view, showing position and character of the aperture.

7, 8, 9—*Discorbis correcta* Carsey, ×90. Three specimens from exposure at the mouth of Boguechitto Creek, Locality 106. 7, Dorsal view, showing evolute coiling. 8, Peripheral aspect. 9, Ventral side, illustrating aperture at the edge of last chamber.

10, 11, 12—*Gyroidina soldanii* d'Orbigny, ×90. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 10, Peripheral view, showing convexity of test and apertural face, with aperture extending from near the base to the umbilicus. 11, Dorsal face, showing evolute coiling. 12, Ventral aspect, illustrating umbilicus.

13, 14, 15—*Gyroidina alabamensis* Sandidge, n. sp., ×130. Holotype from exposure at the mouth of Boguechitto Creek, Locality 106. 13, Ventral view, showing the prominent umbilical cavity. 14, Peripheral view, giving generally conical appearance of test and showing the character of the aperture. 15, Dorsal face, illustrating evolute coiling and oblique angle of transverse sutures.

16, 17, 18—*Gyroidina depressa* (Alth), ×80. Specimen from Red Bluff, Locality 105. 16, Ventral view, showing smoothness and transparency of test. 17, Peripheral view, showing compression of test and character of aperture. 18, Dorsal view, showing evolute coiling and type of sutures.



Sandidge, Cretaceous Foraminifera

GYROIDINA DEPRESSA (Alth)
Plate 43, figures 16–18.

Rotalina depressa ALTH, *1850*, Haidingen's Nat. Abhand. vol. 3, p. 226, pl. 13, fig. 21.
Rotalia cretacea CARSEY, *1926*, Univ. Texas Bull. 2612, p. 48, pl. 5, figs. 7a, b.
Gyroidina depressa CUSHMAN AND CHURCH, *1929*, Proc. Calif. Acad. Sci., Ser. 4, vol. 18, p. 515, pl. 41, figs. 4–6; PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 190, pl. 13, fig. 3; CUSHMAN, *1931*, Tenn. Geol. Surv., Bull. 41, p. 54, pl. 9, figs. 7, 8; *1931*, Jour. Pal., vol. 5, p. 311, pl. 36, figs. 2a–c.

Test round, biconvex, dorsal side low, ventral face more highly convex, periphery rounded, lobate in the later stages; chambers numerous, 11 or 12 in the last whorl, later ones slightly inflated; sutures on dorsal side short and gently curved, impressed between later chambers, on ventral side slightly curved and radiating from the center; umbilicus small, sometimes occupied by a node of shell material; wall smooth, finely punctate; aperture a narrow, elongate slit at the base of the last chamber and extending from the periphery to the umbilicus. Diameter of illustrated specimen, 0.35 mm.

GYROIDINA ALABAMENSIS Sandidge, n. sp.
Plate 43, figures 13–15

Test plano-convex, dorsal side flat, ventral side strongly convex, conical, a small umbilical cavity at the apex, periphery sharply angular, not keeled; chambers numerous, seven in the last whorl, narrow, elongate, spirally coiled; sutures on ventral side flush, curving from umbilical cavity to periphery, on dorsal side slightly impressed, tangent to the penultimate coil, extending obliquely to the periphery; wall smooth, very finely perforate; aperture a narrow elongate slit extending along the inner edge of the face of the last chamber from near the margin into the umbilical cavity. Diameter of the holotype, 0.45 mm.; height, 0.35 mm.

This species closely resembles *Eponides micheliniana* (d'Orbigny) as figured and described by Mrs. Plummer,[17] and *Globorotalia micheliniana* (d'Orbigny) as shown by Cushman.[18] Neither of these forms corresponds exactly to d'Orbigny's original figures of *Rotalina micheliniana*, which has a highly convex ventral side and acute apex with no suggestion of an umbilical cavity. Since d'Orbigny's type specimen is reported to have been lost, the validity of *Eponides micheliniana* and of *Globorotalia micheliniana* both may be questioned. Whether or not these forms belong in the synonymy with *Gyroidina alabamensis* n. sp. cannot be determined until close comparisons of the specimens have been made. The evidence for placing the Ripley species in the genus *Gyroidina* is based largely on its close resemblance to d'Orbigny's models and figures of specimens assigned to this genus, particularly his representation of *Gyroidina soldanii*, which is strongly convex ventrally and has a well defined umbilical opening. This form in its general characteristics also bears a marked resemblance to *Gyroidina girardana* (Reuss), which has an angular periphery. The fact that the aperture extends as a long

[17] Plummer, Helen Jeanne, *Texas Univ.* Bull. 3101, p. 192, pl. 14, fig. 11, 1931.
[18] Cushman, J. A., *Contr. Cush. Lab. Foram Research*, vol. 7, pt. 2, p. 45, pl. 6, figs. 8a–c, 1931.

slit from near the periphery into the umbilical cavity removes the new species from *Eponides*. The very finely punctate, highly polished test easily distinguishes it from *Globoratalia* with its characteristically rough, cancellated shell. Other diagnostic features of the latter genus, such as globigerine characteristics and early chambers like *Globigerina*, also are lacking in *Gyroidina alabamensis*. The species occurs abundantly in the Ripley formation and holds promise of being a very useful guide fossil.

The holotype is from exposures at the mouth of Boguechitto Creek, on Alabama River (Locality 106).

Family CHILOSTOMELLIDAE

Genus PULLENIA Parker and Jones

PULLENIA QUATERNARIA (Reuss)

Plate 44, figures 16, 17

Nonionina quaternaria REUSS, *1851*, Haidinger's Nat. Abh., vol. 4, pt. I, p. 34, pl. 2, fig. 13.

Pullenia quaternaria CUSHMAN, *1931*, Tenn. Geol. Surv., Bull. 41, p. 57, pl. 10, figs. 5a, b; *1931*, Jour. Pal., vol. 5, p. 313, pl. 36, figs. 4a, b.

Test nearly spherical, coiled, bilaterally symmetrical; chambers numerous, forming several convolutions, five in each whorl, completely embracing so that only the last coil is visible, gradually increasing in size as added; sutures in early stages appearing as narrow, dark lines, very slightly impressed between last two chambers; wall finely punctate, surface smooth; aperture a narrow, slightly arched slit extending across the periphery at the base of the last-formed chamber. Diameter of the illustrated specimen, 0.28 mm.

Family GLOBIGERINIDAE

Genus GLOBIGERINELLA Cushman

GLOBIGERINELLA VOLUTA (White)

Plate 44, figures 1, 2

Globigerina aequilateralis CHAPMAN, *1896*, Jour. Roy. Micro. Soc., p. 589, pl. 13, fig. 7.—EGGER, *1899*, Abh. kön. bay. Akad. Wiss., München, Cl. II, vol. 21, p. 169, pl. 21, figs. 9, 11.

Globigerina voluta WHITE, *1928*, Jour. Pal., vol. 2, p. 197, pl. 28. fig. 5.

Test plano-spiral, loosely coiled, bilaterally symmetrical, consisting of about one and a half volutions; chambers numerous, inflated, globular, increasing in size as added; sutures deeply impressed; wall reticulate, bearing numerous fine spines; aperture a large arched opening at the base of the last chamber. Diameter of illustrated specimen, 0.3 mm.

Family GLOBOROTALIIDAE

Genus GLOBOTRUNCANA Cushman

GLOBOTRUNCANA CANALICULATA (Reuss)

Plate 44, figures 3–5

Rosalina canaliculata REUSS, *1854*, Denkschr. D. K. Akad. Wiss. Wien vol. 7, p. 70, pl. 26, figs. 4a, b.

Globigerina linnaeana PARKER, JONES, AND BRADY, *1895*, Foram. of the Crag. pt. II, p. 285, pl. 7, figs. 23a, b.

Globigerina canaliculata EGGER, *1899*, Abh. kön. bay. Akad. Wiss., München, Cl. II, vol. 21, p. 172, pl. 21, figs. 15–17, 24–26.

Globotruncana canaliculata CUSHMAN, *1927*, Contr. Cush. Lab. Foram. Res., vol. 3, pt. 2, p. 116, pl. 23, figs. 11a, b, c.

Test trochoid, dorsal side flat, ventral side convex, excavated at the umbilicus, periphery truncate, flat, a keel at each edge, scalloped; chambers in early stages very small and slightly inflated, later flattened dorsally, lobate ventrally, flattened at the sides bearing a double row of very

fine beads which form keels at the angles; sutures raised, formed by the keeled edges of the chambers; wall punctate and very finely spinose; aperture ventral, opening into the umbilical cavity. Diameter of illustrated specimen, 0.45 mm.

GLOBOTRUNCANA ARCA (Cushman)

Plate 44, figures 6–8

Pulvinulina arca CUSHMAN, *1926*, Contr. Cush. Lab. Foram. Res., vol. 2, pt. 1, p. 23, pl. 3, figs. 1a–c.

Globotruncana arca CUSHMAN, *1927*, Contr. Cush. Lab. Foram. Res., vol. 3, pt. 1, p. 91, pl. 19, fig. 11; *1931*, Tenn. Geol. Surv., Bull. 41, p. 59, pl. 11, figs. 6a–c.—PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 195, pl. 13, figs. 7–9.

Test round, equally biconvex in early stages, later becoming more convex ventrally, umbilicate, composed of numerous closely coiled chambers, all chambers visible on dorsal side, only those of the last whorl on ventral side, periphery truncate, bordered by a double keel in early stages, later becoming single, sutures distinct, on the dorsal side limbate, ornamented with small beads, curving from the periphery toward center of the coil, outer edges forming the dorsal keel of the test, on the ventral side depressed, curving in hook-like fashion toward center, joining umbilicus; aperture on ventral side at the base of the last-formed chamber, opening into the umbilicus. Diameter of illustrated specimen, 0.5 mm.

GLOBOTRUNCANA FORNICATA Plummer

Plate 44, figures 12, 13

Globotruncana fornicata PLUMMER, *1931*, Univ. of Texas, Bull. 3101, p. 198, pl. 13, figs. 4–6.

Test generally circular in outline, margin scalloped, truncate, bordered by a double keel, biconvex, all chambers visible on dorsal side, only last whorl visible ventrally, umbilicate on ventral side; chambers numerous, four or five in last whorl, cresent shaped in later stages, rather flat on dorsal side with a slight crenulation extending across widest part, somewhat inflated ventrally, ends overlapping; sutures curving gracefully from margin toward center of test, limbate on dorsal side, ornamented with very small beads or spines, smooth and impressed ventrally; surface of test covered with very small papillae or fine spines; aperture at the base of the chambers on ventral side, opening into umbilicus, a short flap sometimes present. Diameter of illustrated specimen, 0.4 mm.

GLOBOTRUNCANA CONVEXA Sandidge, n. sp.

Plate 44, figures 9–11

Test trochoid, umbilicate, highly convex dorsally, convexity less pronounced on ventral side, periphery lobate, keeled, sides only slightly truncate, a poorly developed secondary keel at the ventral margin; chambers in very early stages globigerine, closely coiled, increasing in size as added, later ones petalloid and smooth on dorsal side, outer margin carinate, acutely lobate on ventral side, forming a sharp ridge around the umbilicus; sutures slightly limbate dorsally, limbation formed by carinate margins of chambers, impressed ventrally; wall finely papillose; aperture opening into the um-

bilical area; umbilical cavity large. Diameter of the holotype, 0.32 mm.

This species resembles very old specimens of *Globotruncana arca*, but it may be distinguished from them by its more pronounced dorsal convexity, and the distinctly petalloid appearance of the later chambers. The last few chambers frequently bear a slight transverse depression near the middle.

The holotype is from Red Bluff, on Alabama River (Locality 105).

ANOMALINA TAYLORENSIS Carsey

Plate 44, figures 14, 15

Anomalina taylorensis CARSEY, *1926*, Univ. of Texas, Bull. 2612, p. 47, pl. 6, figs. 1a, b.—PLUMMER, *1931*, Univ. of Texas, Bull. 3101. p. 202.

Planulina taylorensis CUSHMAN, *1931*, Tenn. Geol. Surv., Bull. 41, p. 62, pl. 12, figs. 5a–c; *1931*, Jour. Pal., vol. 5, p. 314, pl. 36, figs. 6a–c.

Test nautiloid, dorsal side somewhat concave, ventral side convex, periphery acute, usually bordered by a rim of clear shell material, slightly lobate; chambers numerous, forming from 2 to $2\frac{1}{2}$ whorls, 11 to 12 in the last coil, curving slightly on the dorsal side, V-shaped on the ventral side with the apex produced and extending to the umbilicus, turning back slightly and successively overlapping; sutures in early stages limbate, especially prominent on the ventral face, last few impressed, distinct; umbilical area on the dorsal side filled by a knob of clear shell material, marked on the ventral face by an irregular mass of the same material; wall coarsely perforate; aperture an elongate opening beginning on the periphery and extending on the ventral side under the

EXPLANATION OF PLATE 44

FIGS. 1, 2—*Globigerinella voluta* (White), ×96. Specimen from Red Bluff, Locality 105. 1, Side view, showing early coils at center. 2, Perpipheral view, illustrating the aperture.

3, 4, 5—*Globotruncana canaliculata* (Reuss), ×42. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 3, Dorsal view, illustrating strong limbation of sutures, and lack of convexity on this face. 4, Ventral aspect, showing umbilicus. 5, Peripheral view, illustrating the well-defined double keel and sharply truncate margin.

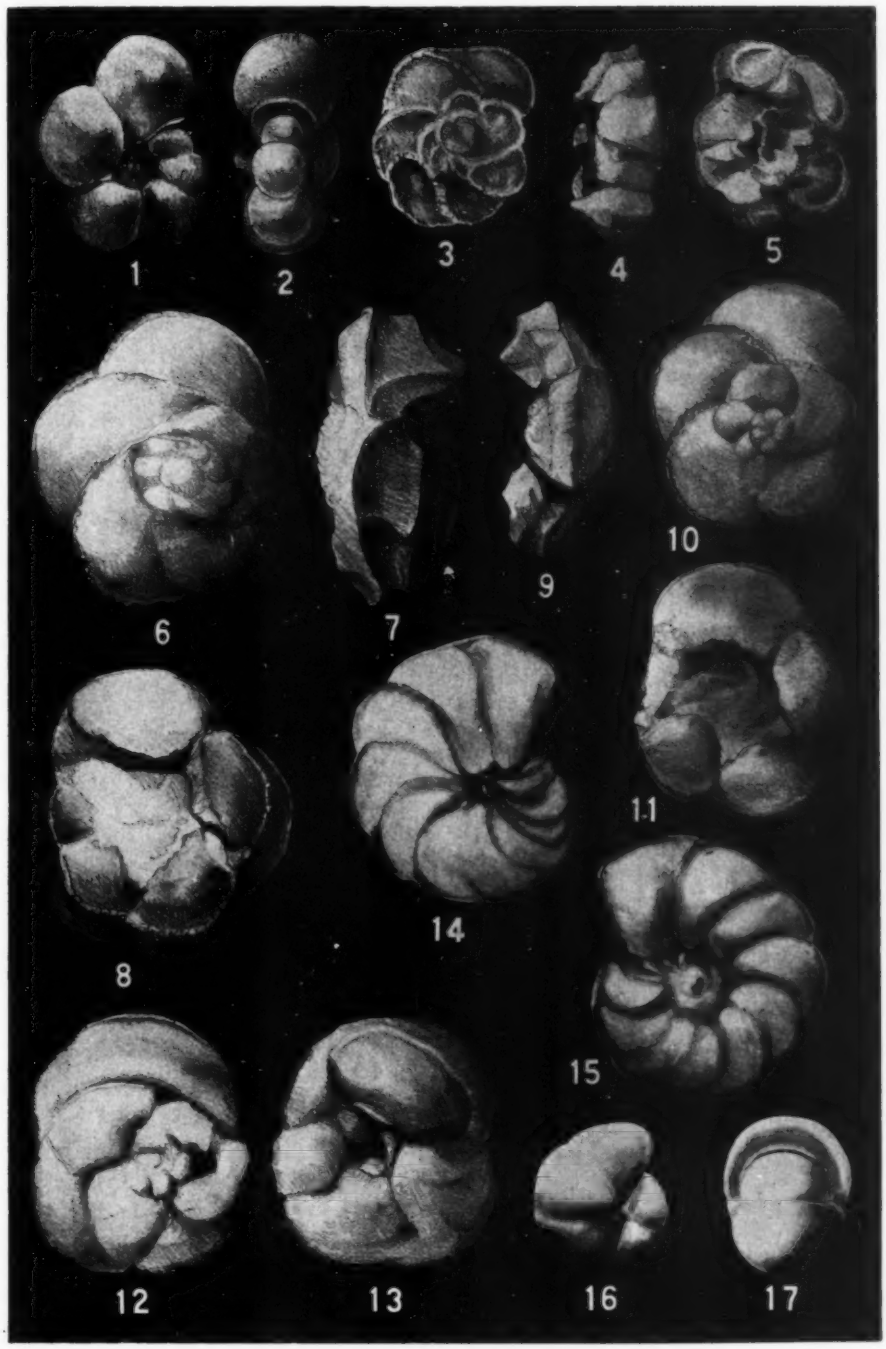
6, 7, 8—*Globotruncana arca* (Cushman,) ×96. Specimen from exposure at the mouth of Boguechitto Creek, Locality 106. 6, Dorsal side, showing large beads on sutures. 7, Peripheral aspect, illustrating double keel and truncate margin. 8, Ventral view, showing umbilicus and well-defined double keel.

9, 10, 11—*Globotruncana convexa* Sandidge, n. sp., ×100. Holotype from Red Bluff, Locality 105. 9, Peripheral view, showing convexity of dorsal face, narrow truncation of margin, and sharp edges of chambers around the umbilicus. 10, Dorsal view, illustrating regularly curving sutures, globigerine early chambers, and petalloid later chambers. 11, Ventral aspect, showing large umbilicus, and lobate margin.

12, 13—*Globotruncana fornicata* Plummer, ×85. Specimen from Red Bluff, Locality 105. 12, Dorsal view, illustrating finely beaded and strongly curving sutures. 13, Ventral side, showing small umbilicus and truncate margin.

14, 15—*Anomalina taylorensis* Carsey, ×35. Specimen from Barton's Bluff, Locality 53. 14, Ventral view, illustrating overlapping flaps of chambers. 15, Dorsal aspect, showing slightly evolute character and central knob.

16, 17—*Pullenia quaternaria* (Reuss), ×72. Specimen from Red Bluff, Locality 105. 16, Side view, showing five slightly inflated chambers. 17, Apertural view, illustrating rotund shape of test.



Sandidge, Cretaceous Foraminifera

V-shaped flap of the last chamber into the umbilicus. Diameter of illustrated specimen, 1.0 mm.

Typical specimens of this species from the Taylor formation of Texas, as well as specimens from the Ripley formation in Alabama, definitely have the characteristics of *Anomalina* as defined by Cushman in his 1928 classification,[19] and resemble *Planulina* only in their marked compression. The species is involute ventrally and partially involute dorsally, as provided for in the generic definition referred to, while by the same authority *Planulina* is defined as an evolute form with the earlier chambers visible from both sides of the test. Also there is a difference in the characteristics of the apertures, the aperture of *Planulina* being at the base of the last chamber at the median line, whereas that of *Anomalina* is ventral in early stages, extending to the periphery in the adult. These characteristics of the genus *Anomalina* are clearly shown in the accompanying illustrations of *Anomalina taylorensis* Carsey from the Ripley at Barton's Bluff, on the Tombigbee (Locality 53). The species occurs abundantly in this formation in Alabama.

[19] Foraminifera, Their Classification and Economic Use, *Cush. Lab. Foram. Research*, Spec. Publ. 1, April, 1928.

JOURNAL OF PALEONTOLOGY, VOL. 6, NO. 3, PP. 288–295, FIGS. 1–13, SEPTEMBER, 1932

ORIENTATION OF THE CARAPACES OF PALEOZOIC OSTRACODA

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If one endeavors to find the proper orientation of a carapace of a living species of ostracode, then the part where both valves are movably joined is to be regarded as dorsal, or upper; the opposite part forms the ventral, or lower side. The anterior end is indicated by the cephalic part of the animal, which is indicated by the antennae and antennulae, whereas the rear end lies opposite to it and may also be determined by the furca.

The orientation of Tertiary and Mesozoic Ostracoda is usually easy to determine, for they belong mostly to genera of which species still exist (for example, more than 100 species that occur in the Cretaceous of South Limburg). Little as to orientation can be said with certainty, however, in the case of the "pot-with-lid" type and of a few species in which each valve possesses a median furrow.

Among Paleozoic Ostracoda, most species belong to genera that have no living representatives. The dorsal part, where the valves articulate, is easy to recognize in most cases, as the edges of the valves are straight. Opposite the hinge-line is the ventral part. Opinion differs as to determination of the anterior and posterior ends of the carapace. Ulrich and Bassler, who are joined in this by Kummerow and Matern (*12*, p. 10), usually designate as anterior the end of the carapace that I call posterior. I have explained in detail my manner of determining the anterior end of the carapaces[1] and subsequently Dr. Kummerow has disputed my method.[2]

The purpose of this paper is twofold. First, I wish to communicate two facts which in my opinion point to the correctness of my manner of orienting the Paleozoic ostracodes. These are complementary to my preceding paper, therefore. In the second place, I desire to offer some remarks on the paper by Kummerow. I will then have explained my opinions on the question as far as is now possible. As I am at present engaged in a study of the Cretaceous Ostracoda of South Limburg, and as this will occupy me for some time to come, I shall probably devote no more attention to this question. In my opinion the problem of correct orientation of Paleozoic ostracodes can only be solved by studying the Paleozoic species closely and by comparing these with what we know of the younger fossil and living Ostracoda. It will probably then be found

[1] *Jour. Pal.*, vol. 4, no. 2, 1930.
[2] *Jour. Pal.*, vol. 5, no. 2, 1931.

that I have led the research in the right direction, in which opinion I am confirmed by Kummerow's paper.

OBSERVATIONS SUPPORTING BONNEMA'S METHOD OF ORIENTATION

My theory as to the correct manner of orienting the carapaces of Paleozoic Ostracoda receives support from the two following facts.

(1) The peculiar articulation of the two valves (namely that one valve has a process at the hinge-line

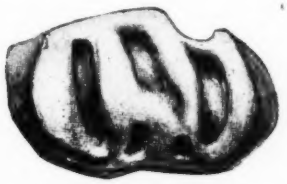

FIG. 1. Right valve of *Poloniella hieroglyphica* A. Krause sp., ×40.

which fits into a corresponding depression in the opposite valve) in *Poloniella* (=*Dizygopleura*) and other genera of the family of the Kloedenellidae (*4*, p. 1089; *5*, p. 1106; *16*, p. 312; *6*, f. 5, 6) (fig. 1) is found at the anterior end, according to my manner of orientation, and at the posterior end according to the views of my opponents. This articulation is best adapted for its purpose if it is at the anterior end. If on the contrary, it were at the posterior end, then the two valves would easily open at the anterior end during movement through the water. In the shells of the genera *Solen* and *Ensis* of the Pelecypoda, where the hinge shows some resemblance, the articulation is also as far forward as possible. Employing this criterion as I interpret its significance, the carapaces of these Ostracoda have the

FIG. 2. Right valve of a female *Cytherella* (*?*) n. sp., ×30.

same orientation as is indicated by sex-dimorphism in *Poloniella hieroglyphica* Krause and *P. devonica* Gürich.

(2) The most remarkable ostracode (figs. 2–6) in the Cretaceous of South Limburg, to be described shortly by Miss van Veen, is related to species of the genus *Cytherella*. This is sufficiently shown by the manner in which sex-dimorphism

FIG. 3. Right valve of a female *Cytherella* (*?*) n. sp. from the dorsal side, ×30.

occurs and by the fact that the right valve is larger than the left. The valves, however, have concentric bands, somewhat like those observed in *Eridoconcha* (*16*, p. 297; *12*, p. 13) from the Ordovician, Silurian and Devonian. Moreover, the carapace has a thick wall composed of two

layers, the exterior of which decays much more easily than the interior, so that usually only the latter is still

FIG. 4. Right valve of a female *Cytherella* (*?*) n. sp., from the anterior side, ×30.

present. This occurs also in some species of *Cytherella*. Curiously enough, the carapace then greatly resembles that of an Ordovician *Bollia* (*1*, pl. 4) to which an orientation has been given in accordance with the rules laid down by me. The median furrows are on the anterior part of the carapace. The right valve is, however, larger than the left, as is the case in *Cytherella* and related

FIG. 5. Carapace of a male *Cytherella* (*?*) n. sp., the outer layer lacking, from the right side, ×30.

genera. This last fact I consider to be a secondary character, however, as in the case of *Leperditia*.

DISCUSSION OF KUMMEROW'S PAPER

I may make the following short remarks in answer to the paper by Kummerow.

(1) According to Kummerow, the cavities in *Primitia tolli* Bonnema are too large to have contained the eyes. This objection I cannot share. Not only do Ulrich and Bassler say that the lateral eyes are large (*16*, p. 272); but in living Ostracoda, such large eyes are also found, e.g. in *Cylindroleberis teres*. (*13*, pl. 8. fig. 5). That these cavities in *Primitia tolli* have contained eyes, I conclude from their location, their circular shape, the thinness of the wall at these points, and from the fact that the

FIG. 6. Carapace of a male *Cytherella* (*?*) n. sp., the outer layer lacking, from the dorsal side, ×30.

valves are "Uhrglasartig vorgewölbt."

The cavities have quite another form in *Cytherellina*, and the adductor muscles are attached to the bottom of them (*1*, p. 74).

That the tubercles of *Primitia esthonica* Bonnema contained eyes which filled these completely, I do not consider probably. I regard it as more likely that these tubercles must be derived from such as are found in *Primitia tolli* Bonnema.

(2) In regard to the points of attachment of the adductor muscles, I may mention that I have never had any trouble in finding these. Generally, they can be recognized easily on

the exterior of the valves (*6*, f. 13, 14), and on the inside this is always the case, for these points have a different color from other parts of the valves (*1*, pl. 3 figs. 17, 18, 24, 25; pl. 6, figs. 15, 16). In a carapace with median furrows, such as are common among the Beyrichiacea, the points of attachment of the adductor muscle are located on the internal ridges that correspond to the median furrows. The location of the points of attachment of the adductor muscle

FIG. 7. Right valve of *Nesidea* (*?*) n. sp. from the exterior side, ×30.

is therefore always the same as those of the median furrows, and I therefore think that these furrows originated through the action of the adductor muscle.

That the location of these points in living ostracoda is usually on the anterior part of the carapaces, and in Paleozoic forms on the posterior end, is very improbable. The former orientation seems to be the more reasonable.

Kummerow assumes here, that the Beyrichiacea are "an extinct opposite ostracoda group that is quite strange to present-day forms," with which opinion I do not agree. Moreover, he says at the beginning of his paper that the comparison of the fossil Paleozoic Ostracoda with the living ones leads him to conclusions contrary to mine. In my opinion, one

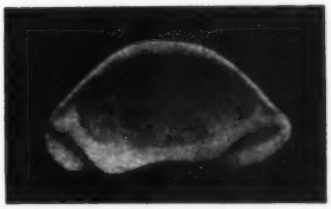

FIG. 8. Right valve of *Nesidea* (*?*) n. sp. from the interior side, ×30.

might then have expected him to give the Paleozoic Ostracoda the same orientation as I do.

(3) To Kummerow, the most important factor is the location of the brood pouches. He thinks it impossible that the end where these are located should be the anterior end of a free-swimming animal, as would be the case with the orientation of Paleozoic Ostracoda that I have pro-

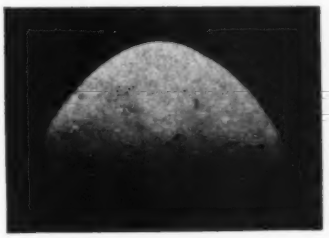

FIG. 9. Left valve of *Nesidea* (*?*) n. sp. from the exterior side, ×30.

posed. With regard to this it may first of all be remarked that it may just as well be assumed that the female Ostracoda crept on the bottom as that they swam freely.[3] Moreover, the brood pouches would also have

[3] See discussion by Müller at end of this paper.

exerted a fairly great resistance if they had been located on the rear end. At the same time it should not be forgotten then that they could have performed their function just as well if located on the anterior end as on the posterior, since they communicated directly with the inner

FIG. 10. Left valve of *Nesidea* (*?*) n. sp. from the interior side, ×30.

cavity of the carapace. This would have been otherwise if they had opened outwards, as is the case with the females of *Primitiopsis*. Here it was more efficient that they should be located on the posterior end. Here, too, one must be cautious, as a species of *Nesidea* (*?*) from the Cretaceous from South Limburg (figs. 7–10) seems to have a brood (?) space on the anterior and on the posterior part of each valve. Moreover, it may be remembered that in the living ostracode *Chlamydotheca speciosa* Dana (*14*, p. 184) (fig 11) at both ends of the carapace a brood (?) space is found and in *Chlamydotheca incisa* Claus (*14*, p. 184) (fig. 12) only at the anterior end.

A recent statement of Salomon-Calvi is probably applicable here (*15*, p. 133). He remarks:

Die wissenschaftliche Entwicklung hat schon oft dem sogenannten "gesunden Menschenverstande" Faustschläge erteilt. War es nicht ungeheuerlich die Erde die man für eine Scheibe gehalten hatte in eine Kugel zu verwandeln auf deren Gegenseite die Antipoden mit dem Kopf nach unten hingen?

(4) On the subject of Kummerow's (*10*, p. 425) discussion of the manner of development of the brood pouches, I would remark that beyond doubt these evolved in *Primitiopsis planifrons* Jones in a fashion different from that which he states. The space in each valve in the case of the females of this species is not divided into two parts by a cross-wall, as is also assumed by Jones (*8*, p. 5; *9* p. 407) and Chapman (*7*, p. 154), but a crescentic internally concave border has been formed in the prolongation of the lateral surface of each valve. This is also the opinion of Ulrich and Bassler (*16*, p. 278). The brood-space is therefore certainly to be compared

FIG. 11. Adult female of *Chlamydotheca speciosa speciosa* Dana, viewed from left side (after Sars) ×15.

with that of the Eurychilininae (*10*, p. 426). That the outer wall of the brood-space is not a part of the real wall of the valve is rendered probable by the fact that it is smooth, whereas the real wall is ornamented. Moreover, I think I remember finding that in other species of *Primiti-*

opsis the outer walls of the brood-spaces of the two valves often do not touch each other when the carapaces are closed. This is the case with *Primitiopsis planifrons*. In *Primitiopsis oblonga* Jones and Hall, there is a small aperture at the rear end. Twenty years ago I was engaged in studying this genus, and then found some interesting facts. For lack of time I had to break off this research, but perhaps it will be possible for me to complete it later.

(5) As in Paleozoic Ostracoda, the carapace is given an orientation which agrees with the accepted criteria, the number of exceptions with regard to the relative size of the valves in the two cases is, of course, small. It must not be concluded from this that the relative size of the two valves cannot be used to determine which orientation of the carapaces must be given to the Paleozoic Os-

FIG. 12. Adult female of *Chlamydotheca incisa* Claus, viewed from left side (after Sars) ×15.

tracoda. The fact that in living forms the left valve is generally the larger tells, in my opinion, in favor of the assumption that the carapaces of the Paleozoic Ostracoda have to be orientated in such a way that the left valve is the larger.

(6) Kummerow seems not to know that I (*4*, p. 1090; *5*, p. 1107) formerly demonstrated in the ostracodes which he calls *Kloedenella halli* Jones and *Kloedenella pennsylvanica* Jones, the same peculiar articulation of the valves which also occurs in *Poloniella hieroglyphica* Krause and *Poloniella devonica* Gürich. Ulrich and Bassler afterwards combined the species where this articulation is found, to

FIG. 13. Left valve of *Poloniella halli* Jones (after Jones) ×15.

form the family Kloedenellidae (*16*, p. 312), which they divide into several genera. To this family belong the genera *Kloedenella* and *Dizygopleura*. The genotype of the former is *Kloedenella pennsylvanica* Jones, and to the latter, of which, *Dizygopleura swartzi* Ulrich and Bassler is the genotype and *Dizygopleura stosei* Ulrich and Bassler is shown in the figure, belongs the ostracode which Kummerow calls *Kloedenella halli* Jones (fig. 13). Now these two latter resemble *Poloniella hieroglyphica* Krause so closely that, in my opinion, *Poloniella* and *Dizygopleura* are identical. As *Poloniella* was established first, the genus *Dizygopleura* must be abandoned. According to Kummerow, the species of *Dizygopleura* have the characteristic beyrichiacean lobation, but in that case it is not to be wondered at that I assume the same in regard to *Poloniella* (*12*, fig. 1). I consider myself

quite justified in determining the orientation of the carapaces of *Beyrichia*, *Ctenobolbina*, *Tetradella*, and *Ceratopsis* by means of what I have found in the genus *Poloniella*.

(7) It may also be pointed out that the fact that the criteria employed point in the same direction is no proof of their correctness, for this is also the case when the direction is the wrong one (*16*, p. 284).

Prof. G. W. MÜLLER, the best student of living Ostracoda, writes in one of his last publications (Ostracoda, *Handbuch der Zoologie gegründet von Kückenthal, herausgegeben von Krumbach* Bd. III, 1927).

Bewegung.—Zahlreiche Formen sind an den Grund gebunden, so alle Podocopa (with their so numerous species) alle Polycopiden, zahlreiche Cypridiniden. Von diesen graben sich zahlreiche Formen in den Grund ein, und zwar mit Hilfe von Antennula oder Antenne, Mandibel und Furka (Cypridinidae) oder fast ausschlieszlich der Antennula (zahlreiche Cytheridae). Manche Arten scheinen eine überwiegend unterirdische Lebensweise zu führen (Cypridinidae). Andere Arten, besonders Cytheridae und Cypridae, bewegen sich kriechend über dem Grund, wobei die Antenna die Hauptrolle spielt, sind nur zum Teil befähigt, an Pflanzen herumzuklettern, letzteres zahlreiche Cypridae, manche Cytheridae, Paradoxostoma und so weiter (p. 424).
Bewegungsorgane.—Auszenast der Antenne verschiedener Cypridiniden (*Philomedes*, *Sarsiella*) beim Männchen besser zum schwimmen, beim Weibchen besser zum Eingraben geeignet. Schwimmborsten der Antenne bei den Männchen mancher Cypriden besser entwickelt, Spinnborste der Antenne beim Weibchen mancher Cytheriden zurückgebildet. Furka bei den Asteropinae bei Weibchen kräftiger bewaffnet (Grabfunktion); hierher wohl auch manche Unterschiede in der Schalenform (Sarsiella, Philomedes) (p. 426).
Nach der Begattung verlieren die Weibchen mancher Cypridiniden (Arten der Gattung *Philomedes*) die Schwimmborsten, sie beiszen sie sich ab(?) und verlieren die Fähigkeit des Schwimmens (Analogie mit den Weibchen der Ameisen) (p. 429).

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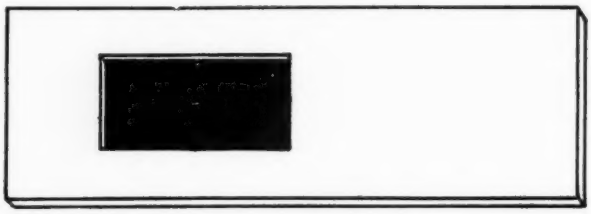

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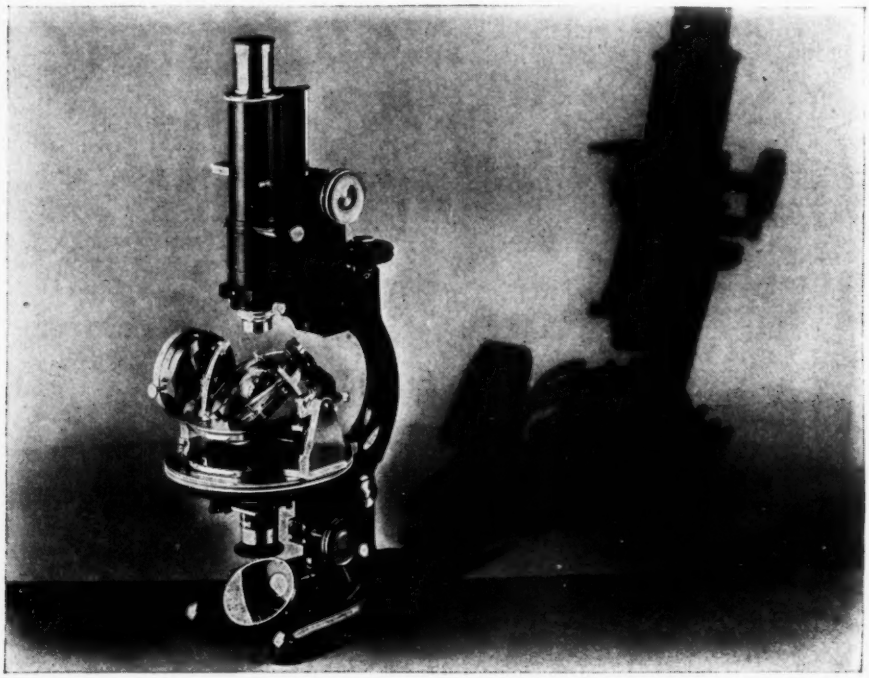

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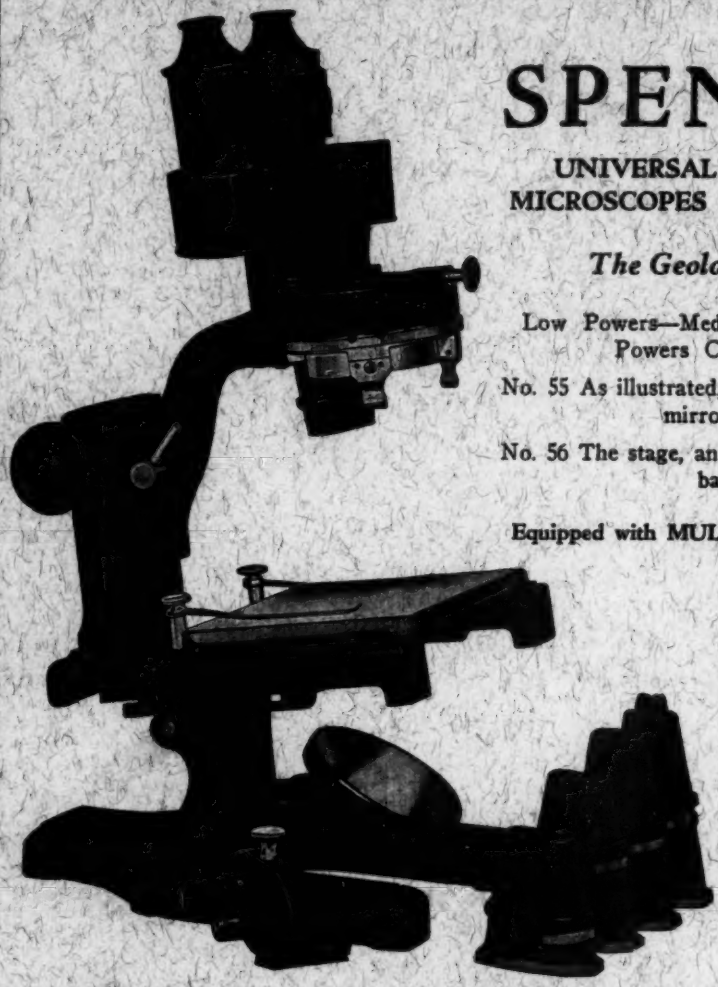

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